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SKETCHES

OF

THE PHILOSOPHY

OF

LIFE.

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SKETCHES

OF

THE PHILOSOPHY

OF

LIFE.

BY

SIR T. C. MORGAN, M.D.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS, OF LONDON.

Ῥεῖν τὰ ὅλα ποταμοῦ δίκην.

Il n'y a point de doute que les besoins physiques ne dépendent immédiatement de l'organisation; mais les besoins moraux n'en dependent ils pas également, quoique d'une manière moins directe ou moins sensible?

Cabanis Rapport du Physique et du Moral de l'Homme.

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SKETCHES

OF THE

PHILOSOPHY OF LIFE.

PRELIMINARY REMARKS.

Χρὴ πάντας ’ανθρώπους ’ιητρικὴν τέχνην ’επιστασθαι, ὦ ‘Ιππόκρατες, καλὸν γὰρ ἅμα καὶ ξυμφέρον ’ες τὸν βίον . . . . ἱστορίην σοφίης γὰρ δοκέω ἰητρικῆς ἀδελφὴν καὶ ξυνοίκον.

Democriti Epistola ad Hippocratem de Natura Hominis.

“ The knowledge of truth is the sovereign good of human nature.” *Bacon’s Essays.*

OF the various modes of exertion incidental to the necessities of the species, the labour of thinking, it would appear, has ever been considered the most intolerable; and society, in all ages, has been prompt to lend credence and to bestow recompense upon those who are willing to take upon themselves the task of dictating the opinions, and of regulating the conduct of the rest of the community.

Despotic government, juridical, religious and medical imposition, are the fruit of this intellectual indolence; and even the passion for accumulating wealth, which seems impressed on man as an instinct, and for which all other interests are so generally abandoned, is thus turned aside from its obvious end, and becomes a burden imposed upon the many for the exclusive benefit of the few.

The profession of Physic, more especially, has been stigmatised as peculiarly susceptible of dupery and deceit, and the extreme ignorance which has universally prevailed on the subject justifies the accusation.* In the earliest epoch of its history, this lucrative branch of science was in the possession of the priests, who added to the fascinations of its own intrinsic mysteries the spells of a still more unintelligible superstition. The votive offerings which lined the walls of their temples prove that their success was at least equal to their ignorance.† When the two professions were separated, the practice of physic seems to have been abandoned to the lowest classes of society, and to have been frequently placed in the hands of slaves. Horace associates its professors with gypsies and other similar impostors;* and Athenæus tells us, that Aristotle himself became a doctor, upon the failure of what probably were considered more honorable means of subsistence.† It is only since knowledge has been more equally diffused by the art of printing, that physic and surgery have been elevated to real utility. For as the reformation in religion, by habituating the people

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* "Itaque hercule, in hac artium solâ evenit, ut cuicunque medicum se profitenti statim credatur; cum sit periculum in nullo mendacio majus."

Plinii Hist. N. 29. 1.

† Among the works of the ancient physicians which have been preserved, the writings of Hippocrates alone are con-

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ceived in a philosophical spirit. Democritus, who probably lost his sight by an excessive use of its organs (for the story of his putting out his own eyes is too absurd for belief) seems to have understood the right method of investigating nature; but his works have unfortunately not survived. The other Greek philosophers mingled their scanty knowledge of physiology with their own visionary theories; and the professed medical writers copied each other with provoking servility."

* Sat. II.

† 'Ειδὼς καὶ 'Επίκουρον τὸν φιλαληθέστατον, ταῦτ' ειπόντα περὶ αὐτοῦ ('Αριστοτέλους) ἐν τῇ περὶ ἐπίτηδευμάτων 'επιστολῇ, ὅτι καταφάγων τὰ πατρῷα, ἐπὶ στρατείαν ὥρμησε, καὶ ὅτι ἐν ταύτῃ κακῶς πράττων, ἐπι τὸ φαρμακοπωλεῖν ἦλθεν.

Athenæi Deipn. VIII.

The pharmacopola was analogous to our quack doctor; and, as appears from an observation of M. Cato, was equally verbose and high-promising. "Itaque auditis non auscultatis, tamquam pharmacopolam; nam ejus verba audiuntur; verum ei se nemo committit si æger est."

Apud Aul. Gell.

to moral and polemical discussion, forced the priesthood to abate from the arrogance of their pretensions, to cultivate learning and to practice piety, so the dissemination of natural science has diminished quackery in medicine, and urged the regular practitioner to extend his observations beyond the superstitious routine in which, as in a magic circle, his energies were heretofore most scrupulously confined.

But the necessity for a general diffusion of this kind of knowledge is more immediate. The familiar proverb assumes, that every individual "at forty is a fool or a physician;" and after the experience of forty years of error in the management of the constitution, that person may indeed be deemed dull who has not by his sufferings been taught a few maxims of self-government. But the small stock of empyrical knowledge thus acquired is seldom adequate to the intended purposes. It serves rather to generate a quantum of prejudice and obstinacy just sufficient to mislead others, and to baffle the efforts of the medical attendant to whom it is opposed.

The animal machine is an instrument upon which, in the daily occurrences of life, an infinity of experiments are made, by the least of which it is liable to be thrown out of order. Yet persons of all classes in society, the most educated equally with the most uncultivated, persist boldly, blindly, and confidently to apply to it all kinds of re-agents; and to abuse its energies, in absolute ignorance of its springs and modes of action. The treatment of disease, when it arises, can rarely be trusted with safety to other hands than those of the professional practitioner: but its prevention can alone be rendered probable by a clear knowledge of the effects of external agents, and of the real necessities of the machine.

These observations, strongly as they apply to individuals, acquire an additional weight, as they bear upon communities and legislative bodies. Absurd quarantine laws, taxes promoting the adulteration of the necessaries of life, or militating against cleanliness and ventilation, false ideas and absurd enactments concerning madness, poisonings, and infanticide, are a few only, among the many immediate consequences of the gross ignorance which has prevailed, and still does prevail upon this topic.

> Ut teipsum serves, non expergisceris? atqui
> Si noles sanus, curres hydropicus.

Besides these immediate and somewhat obvious interests, there are others, more remote, but not less intrinsically connected with the diffusion of physiological information. The necessities of man, and the means which he possesses of gratifying them, are in immediate dependence upon his organisation. All his relations in society result immediately from the one or the other of these sources, and are corollaries depending upon the laws of organic action. Thoughts and desires are but modifications of those parts, through whose operation they are engendered; and moral motives, like physical stimuli, derive their power from the condition of the structure on which they act. These considerations have hitherto been too generally overlooked. Moralists and legislators, ignorant of their own structure, have persisted in considering mind as abstracted from organization; and have contented themselves with the contemplation of one half only of their subject.

The connection between moral reasonings and physiology has, notwithstanding, been felt by those writers who have the most successfully cultivated the philosophy of mind and of language; and Aristotle, in inventing the appellation of "metaphysics"* for these pursuits, has eternized his sense of the route which best leads to their attainment. But the authority of great names is not wanting to give credence to this proposition. Abundant evidence of its truth is to be found in the deplorable degradation of metaphysical science which followed its removal from the grasp of natural philosophers, and its amalgamation with scholastic divinity. The various successive theories which have flourished since the revival of learning, to explain the phenomena of mind, and to serve as standards for judging of moral codes, have, in their speedy declension and rapid neglect, borne ample testimony to the errors of those methods on which they have been founded. It is alone, as a branch of the natural history of man, that these subjects can be successfully treated: and the rapid and imposing march of mind, under this new direction, leads to the most flattering anticipations of future success. Good and evil are principles intelligible only as they relate to the laws of organic existence. Criminality in morals, like unwholesomeness in medicine, bears immediately upon an interference with the healthy discharge of function, either in the individual or in society; and the adoption of any other criterion for judging of actions, leads immediately to false conclusions and to fatal and destructive prejudices.* With this clue for a guide, it would have been impossible for interested imposture to have substituted absurd ceremonial practices and injurious privations for active benevolence and rational enjoyment; still less, to have arrayed one half of the world in hatred and in warfare against the other; and to have preached massacre and rapine in the name of the Most High. This truth fully developed, the temptation to crime would be materially diminished; except in as far as the imperfection of institutes might render the existence of some individuals incompatible with that of others; an incompatibility, which, when it becomes extensive, leads necessarily and irresistibly to the dissolution of the social bond, and to a remodelling of society. The possession of a canon, it is true, does not always imply its proper application. Strong passions and vehement desires must, under every system, lead inevitably to false conceptions concerning the tendency of actions; but if an agreement with the physical necessities of our nature were made the criterions of moral axiom and legislative enactment, aberrations respecting whole classes of actions could scarcely take place; and individual instances of miscal-

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* Μετα τὰ φυσικα.

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* Hoc autem, de quo agimus, id ipsum est, quod utile appellatur; in quo lapsa consuetudo deflexit de viâ; sensimque eo deducta est, ut honestatem ab utilitate secernens, et constituerit honestum esse aliquid quod utile non esset, et utile,

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quod non honestum; *quâ nulla pernicies major hominum vitæ potuit afferri.—Cicero de Officiis.*

culation would be less frequent, less extensive, and less fatal.

But not to dwell upon speculative and theoretic views, the practical evils which flow from an ignorance of the organisation of the human animal, irresistibly invite to a more diffused acquaintance with the elements of physiology. False notions of the effects of natural agents hurry the body into disease; and the absence of correct ideas on disease places the patient out of all mental relation with the person on whom he trusts for cure. On this subject errors of the most opposite character prevail. Among the great majority the admiration for physic is idolatrous. The favorite oracles of the day are consulted and obeyed with a blindness and credulity truly superstitious. On the other hand a few *esprits forts* treat the art with unmerited contempt, and know not "de plus plaisante momerie, rien de plus ridicule, qu'un homme qui se veut mêler d'en guérir un autre."*

This, indeed, cannot fail to be the case on a subject, concerning which nothing positive is known. To the lower classes a physician is a thaumaturge, a natural magician; the very terms of whose art sound like spells and exorcisms; and even among the more educated, when their medical advisers "savent de fort belles humanités, savent nommer en Grec toutes les maladies, pour ce qui est de les guérir," the patient takes it implicitly on trust.

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* Moliere.

But with these opposite notions of the professor, both classes entertain the same ideas of the art. Both regard the nomenclature of nosology as representing substantive existences, permanent and distinct in their characters, as an horse, a cow, or a dog: Both likewise consider remedies as specifically appropriate to diseases; the one being formed for the other, as a mortise for a tenon; and operating upon it, as water quenches fire. Under these impressions, the great desideratum in sickness is to find a name for the malady; and the failure of the physician is imagined to depend exclusively upon an error in this particular: for the disease being discovered there cannot arise, upon this hypothesis, a difficulty in applying the appropriate remedy; which in all cases should act infallibly, and that too without even co-operation on the part of the patient. With this notion that the temporary application of some wonder-working drug, which is vaunted as "good for such and such a disease," will supersede all necessity for regulating those stimuli which are daily impressed upon the body, exercise and temperance are forgotten or neglected; and, as habitual sins are supposed to be expiated by mortification and prayer at particular seasons, or by an occasional alms-giving, placed on the credit side of the account with heaven ; so health is conceived to be conciliable with great and constant excess, by the cheap intercalation of a temporary submission to the prescriptions of the physician, and a few pounds spent annually with the apothecary. The disappointment of these extravagant expectations has principally perhaps contributed to induce that total contempt, with which many close thinkers regard the practice of physic ; while in feebler spirits, whose hopes are too chimerical to admit of argument, or to yield to conviction, they give rise to the opposite extreme of hunting receipts, and of swallowing whatever is offered, as being nauseous and revolting.

Absolute certainty is in medicine a manifest impossibility. It can rarely exist, except in respect to those simple relations, which can be expressed by numbers. Even the evidence of the senses requires in many cases to be adjusted by other tests. Each individual sees and hears for himself; and every man has his own convictions, which may or may not quadrate with the nature of things; according to Horne Tooke's beautiful explanation of truth, that it is what each person "troweth." Truth indeed must necessarily be, with respect to the human animal, an agreement with appearances; for the intimate nature of things (or absolute and metaphysical truth,) can only abide with that Being from whom nothing is hidden.

In the several natural sciences, in which so much remains, and perhaps ever will remain, undiscovered, an approximation to certainty can only be attained with respect to general propositions; their application to particular cases must almost universally be attended with unforeseen circumstances, which will affect the individual instance, and confer upon it something of peculiarity.

The phenomena of disease are made up in part of the habitual functions of the organs, and in part of perturbations produced by accidental violences. In the infinite repetition of such combinations, the ratio of the perturbing forces to those which are constant, becomes in many cases discoverable. From observations thus made, axioms may be formed, which may be applied with more or less accuracy to each particular case; but they can alone be absolutely predicated, as the average result of very many instances.*

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* Au milieu des causes variables et inconnues, que nous comprenons sous le nom de *hazard*, et qui rendent incertaine et irrégulière la marche des événemens, on voit naître à mesure

Those, who are accustomed to the contemplation of nature, are aware of the difficulty which attends the classification of animals and plants; whose properties are constant and permanently distinct, from generation to generation. This difficulty is rendered materially more embarrassing, when the phenomena of disease are made the subjects of arrangement.—In their nature essentially accidental, the symptoms, which characterize a malady, not only vary in every case, but in every stage of the same complaint. Fugitive and evanescent, they arise, combine in various degrees and modifications, and again subside in the progress of the disease, with a caprice to which the key is but seldom discoverable. The art of medicine therefore, though taught in

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qu'ils se multiplient, une regularité frappante, qui semble tenir à un dessein, et que l'on a considéré comme un preuve de la providence, qui gouverne le monde. Mais en y réfléchissant, on réconnoit bientôt, que cette régularité n'est que le developpement des possibilités respectives des événemens simples, qui doivent se présenter plus souvent, lorsqu' ils sont plus probables . . . . On peut tirer du théorem précédent cette consequence, qui doit être regardée comme une loi générale, savoir que les rapports des effets de la nature, sont à fort peu près, constans, quand ces effets sont considérés en grand nombre. Ainsi malgré la variété des années, la somme des productions pendant un nombre d'années considérable est sensiblement la même.

La Place, Essai sur les Probabilités.

generals, is practised in particulars; and success must vary, not only according to the acquirements, but also to the natural talent of every practitioner.

Another notion, connected with this subject, which appears highly chimerical is, that every disease has its appropriate remedy in nature, if the physician had the ability to discover it. In the practice of surgery, if such a violence has been done to an essential organ as utterly unfits it for its functions, the incurable nature of the accident is readily admitted. In physic such cases perpetually occur, but they are not considered in the same point of view; every internal malady being deemed, in its own nature, curable, provided the art were pushed to its utmost perfection.—The revolutions, which take place from time to time in the phonomena of disease, are very unfavourable to this supposition. New maladies are daily arising, and old forms of complaint disappear, as the progress of society changes the applications, which are habitually made to the living solids, or as the constitution becomes accustomed to those which are more permanent. The use, or the abuse, of certain remedies in like manner introduces accidental combinations of disease, formerly unknown. — Amidst these various changes, it would be absurd to imagine that counter agents exist in the store-house of nature, adapted to every case, and equal to every emergency.

But to return from this digression.—The practical disadvantages of ignorance in matters of health are not merely confined to what respects the professional practice of medicine. Fatal errors are committed in common life, by attributing effects to wrong causes; and much personal inconvenience results from false notions of the tendency of habits, which are adopted for the preservation of health, and are tolerated for salutary effects they do not produce. On the other hand, dangerous and destructive habits are continued from unfounded ideas of security derived from supposed counter agents, which have no real efficacy.—In one word, if ignorance be imbecillity, privation, and suffering, its effects are never more immediate and intimate than when it respects the management of health, and the accidents and affections of the human body.

With an interest thus evident, it may appear strange, that physiology should have shared so little of the attention bestowed by general readers on the several branches of natural science. The solution of this problem most probably lies in the difficulties, in which the subject is supposed to be involved. In all investigations, the first steps are attended with embarrassment. The mind, ignorant alike of the scope of the subject and of the nature of the objects on which it is to be employed, shrinks from the apparent labyrinth that meets its gaze; every thing is strange and unintelligible; facts appear insulated, and are therefore uninteresting; axioms are received with passive assent, and definitions are slowly and imperfectly comprehended. The very organs of sense act not with their full vigour, unstrengthened by use, and unguided by experience. These difficulties apply more particularly to the sciences, whose foundations are laid in the observation of organized nature. In mathematical investigation, there are ideas essentially elementary, which may be presented distinctly from their consequences; but in the works of the creation, there is so close a connection of facts, so universal a blending of causes and effects, that, wherever the beginning is made, from whatever quarter the first approaches are directed, the student finds himself hurried into the middle of the subject, and is compelled, at every step, to feel the want of previous information. In nature nothing is strictly elementary, nothing purely simple; and it is only by voluntary abstractions and by taking much for granted, that artificial elements are made, and a point of departure instituted, which bears the semblance of a beginning.*

The cloudy and obscure countenance, which science thus turns upon her votaries, cannot but disgust the indolent and appal the timid; and avarice or ambition are rendered necessary to engage mankind in a career, whose course is so intricate, and whose aspect is so uninviting. Many more persons are repelled by grammars and first lines, before the heart is moved and the imagination warmed, than by all that is really difficult, uncertain, or contradictory in the most refractory branches of scientific investigation.

To obviate, in some degree, this inconvenience, a different mode of conveying instruction should be adopted, *in limine*, from that generally employed. In communicating the first notions of a science to persons wholly unacquainted with its scope and nature, an opposite course should be followed from that, which has been pursued by inventors, in the first developement of its principles. The progress of discovery is from individuals to generals, from particular experiments and observations to aphorisms, applicable to long series of facts. Every step is made in ignorance of that which is to follow, with the circumspection of diffidence, and the pause of hesitation. It is not till after the lapse of considerable time, and the expence of much labour, that the ground is sufficiently cleared, and an eminence obtained, from which the extent and bearings of a newly discovered country can be ascertained, and the progress of its investigation be appreciated.

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* Εμοι δοκέει ’αρχη μὲν ὄυν ’ουδεμία ε͂ιναι του σώματος, ἀλλα πάντα ὁμόιως ἀρχὴ, καὶ πάντα τελευτη κύκλοὺ γὰρ γραφέντος, ἀρχὴ ’ουκ εὑρέθη.—*Hippocrat de Locis.*

With those that follow, the case is materially different. The region to be crossed has already been explored, the maps have been constructed, and it is not only a more expeditious but a more inviting, and perhaps a more philosophical method to begin with the most general and comprehensive survey of the territory, to descend by degrees, and after having noted the outlines, and observed the bearings of its most prominent features, to study the smaller divisions, and finally to verify the accuracy of those observations, on which the charts, already placed before us, have been constructed by our predecessors.

The early possession of broad and general conclusions, thus obtained, flatters the vanity and interests the imagination of the student, and it operates as an encouragement to his industry.

by at once exciting and gratifying curiosity. This mode of proceeding likewise facilitates the comprehension of the relations which the science itself maintains with the rest of the encyclopædia of human knowledge; it unfolds the "*commune quoddam vinculum*" which connects the whole into one system, and indicates the direction in which the condition of the species may be best improved: the great end and object of all scientific investigation. Slight and general sketches, conducted according to this method, are confessedly ill adapted to convey profound information. Royal roads to knowledge, of every description perhaps, tend to relax industry, and to beget self-sufficiency; *nil sine magno labore* applies no less to the mental, than to the physical wants of the species. But for communicating that sort of information which is required by the general reader, who has neither the time nor the inclination for deeper research, they are abundantly sufficient; and if the intrinsic merits of the pursuit tempt to a deeper examination, they answer as useful pioneers and expediting guides.

In the prosecution of the present work the author has endeavoured to divest it as much as possible of opinions merely theoretical, but the task is by no means easily fulfilled. The difficulty indeed is almost insurmountable of guarding against the dregs and sequelæ of the original bias towards hypothesis. There is this circumstance in common between theology and medicine, that the one turning upon supernatural subjects, totally beyond the reach of human comprehension, and the other embracing the most recondite and elaborate phenomena of nature, they both open a wide field to imagination and to that *nimis magnum studium multamque operam in res obscuras*,* which terminate in a false and deceptive refinement. Learning consequently becomes substituted for knowledge, words are mistaken for ideas, and a constant necessity oppresses the student of examining and re-examining the premises, "*ne incognita pro cognitis habeamus, hisque temerè assentiamus.*" The influence of terms connected with obsolete theories, and of ideas the scattered remnants of shipwrecked hypothesis, is difficultly shaken off. There are some notions which have subsisted so generally among men, that they mix themselves with the common and vulgar language of nations; and the very structure of speech may occasionally mislead the most accurate reasoners. The frequent recurrence of the words "life," "vital forces,"

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* Cicero de Officiis.

"sensibility," &c. &c. which are necessary for expressing the first causes of organic phenomena, insensibly leads the mind to a sort of half conviction that they represent real existences, with which it is perfectly acquainted. Such expressions likewise as "vibrations," "animal spirits," "*sensorium commune*," the fragments of refuted systems, force themselves upon the tongue, and still preserve a certain influence upon the intellect. The sentiment of our absolute ignorance respecting the causes of vital movements, of the intimate nature of all organic phenomena, is the best guard against this tendency to self-deception; and it cannot be too frequently present in the imagination. It is to this branch of enquiry that the aphorism of the poet is particularly applicable: *Sapientia prima est, stultitia caruisse.*

A difficulty not less embarrassing originates in a tendency the very opposite to that of theorizing. Philosophers, like the rest of the species, when they receive a new impulse, though at first hesitating and even reluctant, are eventually borne forward, blindly and unresistingly, in the acquired direction. After a stagnation of nearly two thousand years, the philosophy of Bacon gave a sudden expansion to the mind, which, in overcoming the old disposition towards theoretic method, has ultimately induced a vicious and extensive confidence in experimental deductions.*

In the writings of modern physiologists there appears a strong inclination to reject all general reasonings, and to reduce science to a confused and unconnected heap of jarring and contradictory observations. Amongst the almost infinite number of experimentalists there are but few who exhibit talent for accurate and faithful ratiocination. Every individual collects the results of his own industry into a group, and overlooking or contradicting the experience of his predecessors, comes at once to his own conclusions. Every system of physiology differs from the last; every physician proposes a new method of cure. Agents of the most opposite character are applied under similar circumstances, by different practitioners, "*e sempre bene.*" To decide upon points thus warmly contested, and to assign to reason and experiment those bounds, in which they will best conspire for the advancement of genuine knowledge, are tasks too delicate for that moderate share of talent to which the author of these pages lays claim. Scylla and Charybdis have yawned upon his track; and he has probably been often immerged in both vortices.

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* Quand on a fait une expérience, le meilleur parti est de douter long tems de ce qu'on a vu, et de ce qu'on a fait.

Voltaire des Singularités de la Nature.

The history of the organization and functions of animals, and that of their diseased and irregular actions, form an essential branch of natural history, and are intimately connected with it. The doctrines of chemistry are also of constant application in physiological reasonings. Some slight acquaintance with these sciences is therefore necessary, as a preliminary to the investigation of organic existence. Fortunately this species of information is becoming more extensively disseminated, and is more universally regarded as entering into the scheme of a liberal education; of which fact the progressive introduction of physical images into poetic and oratorical composition affords unequivocal testimony. Elementary works on chemistry and natural history form a part also of every library; and encyclopædias are multiplied in every form, and are adapted to the capacity of every purse. These circumstances supersede the necessity for much preliminary detail, which, though foreign from the scope of the present work, would otherwise be necessary to its illustration.

Physiology in the strictest application of the word, embraces an ample field, and includes an immense variety of matter. Distinct portions of it might afford occupation for a long and laborious life. Details, therefore, in a publication like the present cannot be extended beyond what is absolutely necessary to the general illustration of the outline. It is *the philosophy of physiology* rather than physiological science, which is attempted; and the author, not daring to conduct his reader through the temple of nature, will rest satisfied if he shall have left him at the threshold, prepared to interrogate the goddess, and capacitated for reading her decrees.

CHAPTER I.

OF THE CHARACTER AND CAUSES

OF

ORGANIC COMBINATIONS.

General connexion of existing species in nature—Active powers of matter, mechanical, chemical, vital—Organic and unorganized bodies not in all cases easily distinguishable—Organized bodies, results of inorganic elements, modified by *function*. Hence they have determinate forms, and a circumscribed duration—Death—Equivocal generation—Origin of existing species—Origin of individuals ab ovo—Species circumscribed in number.—Of Living action—Assimilation—Elimination—Peculiarities of organized beings arise out of their chemical constitution—Mechanism of assimilation and elimination—Vascularity of organised bodies—Conditions of assimilation—Living species co-exist by a proportionate harmony—Balance of assimilation and elimination in the different stages of life—Life independent of motion—Organic identity—Assimilation and elimination (the functions of nutrition), and those of generation, all that essentially belong to the idea of life: vegetables do not feel—Sense and motion, the functions of relation or of animal life—Causes of the differences between animal and vegetable forms—Vegetables the result of simpler combinations; therefore more permanent and less dependent on function. Further simplicity of vegetables, resulting from the nature of their food.

CHAPTER I.

OF THE CHARACTER AND CAUSES OF ORGANIC COMBINATIONS.

> "Quella che noi chiamo *distruzione* nella natura, non e che la reduzione delle mazze maggiore in altre minore, et la separazione di sostanze, che lasciano un composito per formarne degli altri nuovi, et comparire sotto nuovi aspetti."
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> *I Campi Flegrei dell' Abate Ferrara.* Sec. 5.

The first attempts at investigating the phenomena of life, were commenced with a sole view to the cure of disease; and the earlier enquiries into organic structure did not extend beyond the anatomy of man and of one or two animals, nearly resembling him.* The more enlarged and comprehensive ideas, derived from a contemplation of the whole series of organized individuals, are the conquest of the present age.

The beneficial influence of this extension of physiological enquiry is not confined to the mere physical history of man; it has brought that science into a more frequent and extended contact with other trains of investigation, and has rendered it a common centre, from which the moralist and metaphysician may deduce notions more stable and conducive to human happiness, than those which their labours have hitherto developed.

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* Human anatomy was not practised till long after the first observations made upon domesticated quadrapeds. Hippocrates mentions, as a matter of boast, the having inspected an human skeleton;—*ἃ δ' ἡμεῖς ἐξ ἀνθρώπȣ ὀστέων κατεμαθομεν.* *Περι ὀστέων φυσιος.*

Considered in insulation, the moral and physical history of man, is an inextricable labyrinth. His various and complicated functions refuse to submit to analysis, and the origin and end of his being are alike placed beyond the reach of definition or conjecture. But when contemplated in connection with the other species, to which he is allied, when viewed as a link in the great chain of existences, he ceases to be an anomaly in creation, and if the mainspring of his movements be hidden in the same night which involves the first causes of all natural phenomena, they are still reducible to a law, of no individual or circumscribed application.

All the various substances, which exist in nature, are possessed of certain powers, by which they exert upon each other a mutual action; and are connected into one whole, in which nothing is strictly and absolutely independent. Inorganic substances exert among each other a *mechanical* action: by which their relative position in space is modified, and the subordinate parts of each are rendered liable to a similar change. They act also upon each other *chemically*, so as to produce new species, by their mutual combinations and decompositions.

Organic bodies, in addition to these mechanic and chemical affections, are influenced by causes, which, without changing their visible structure and arrangement, produce in them deep and intimate modifications ; by which their habits of action are altered, and they become susceptible of impressions, different from those which arise out of their original disposition. Such are the changes which culture produces in the qualities of vegetables ; and such the variations which climate and education impress upon the animal species.

The distinction between organic and unorganized bodies, though sufficiently obvious in extreme cases, is by no means clear in those instances, in which the two classes approximate. This observation applies to all the artificial distinctions which man has imagined for classing the works of nature. Every species is intimately linked with those the nearest resembling it; and abrupt breaks in the series of beings are manifest impossibilities.

The elementary* materials, of which organic species are compounded, are not of a peculiar nature; but enter indifferently as constituents of organic and of unorganised combinations.† The difference between these classes is purely formal; and in the lowest species of living beings, the forms are so simple and the functions so circumscribed, that no firm line of demarcation can readily be drawn between them.

From this consideration, it seems highly probable that there is no basis for the theory, which assigns the movements of organized species to a cause different from the general laws of matter; and which considers the phenomena of life as of another order, from those of inanimate existence.

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* The term 'element' is applied in modern philosophy to such bodies as have resisted all attempts at chemical analysis. The number of substances admitted as elementary is liable to perpetual variations: for the epithet referring to our own powers of operation, and not to qualities inherent in the subject, it becomes applicable, or otherwise, according as the species in question is affected by the progress of chemical research. The analysis of the alcalis, effected by Sir H. Davy, has removed those bodies from the class of elements; and has discovered in their bases, other substances which must be added to the list. The term 'element' must not therefore be taken as conveying a positive assertion respecting the intimate nature of the body, to which it applies. It does not signify *undecompoundable* but *undecompounded.* In this respect it differs from the 'element' of the ancients; to which hypothetical notions were assigned, the fruitful parents of much philosophical error.

† Buffon's theory of organic particles has long fallen into merited neglect; its influence scarcely extending beyond the author with whom it originated.

But whatever may be the theory, the fact is constant, that the formation of organic compounds is the result of a more delicate play of affinities, than that which produces unorganized species. Their existence is maintained by the performance of certain internal motions, which modify the ordinary tendencies of the constituent elements. Between the character of any organized compound and the extent and velocity of these movements, there seems to be a fixed and necessary ratio, by which the complexity and delicacy of elementary constitution are rendered measures of the force and latitude of the living action, by which that constitution is supported. The movements of the vegetable tribes, whose composition is simple, are less complicated and extensive than those of animals; and they admit a longer and more complete suspension, without injury to the individual.

For the performance of vital movements, the parts, in which they take place, have a definite constitution peculiar to each. These several arrangements are called *organs;* and the movements they affect are technically termed their *functions.* Thus digestion is the function of the stomach; the secretion of bile that of the liver. *The sum total of functions, which any individual can perform, constitutes its* LIFE.

As soon as the constituent elements of inorganic combinations are brought into contact, under circumstances favourable to the exertion of their chemical affinities, their union is at once determined; and the new formed substance, susceptible of indefinite duration, is only destructible by the application of external forces. The constituent particles remain in a state of relative rest, and exert no reciprocal action, except that which is termed attraction of cohesion.

Inorganic bodies being thus rendered independent of function, they are freed from the necessity for a definite arrangement.* Their size depends solely upon the number of particles brought within the sphere of mutual action. They may be increased by *accretion*, or diminished by *attrition*, and if broken by violence, the fragments retain all the properties of the original mass, and become so many separate and independent individuals.

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* Crystallization, by many considered as analogous to organic arrangement, differs from it in almost every particular. It is a mere accident and by no means essential to unorganized substances. It is probable, however, that the ultimate particles of all matter may have a definite form, dependent upon that of the elementary atoms. Connected with this supposed analogy is the opinion that minerals grow; a notion, which, though entertained by Linnæus, is founded in an obvious abuse of terms. Unorganized bodies increase only by the superficial addition of new matter.

An inorganic body may consequently exist either under the solid, fluid, or gaseous form, according to its various affections by caloric; passing freely from one to the other of these conditions, without a necessary destruction of its constitution. In organic beings a slight change of form alone is sufficient to suspend action, and dissolve the combination.

Organic compounds being the result of something more than chemical affinity (namely of affinity modified by function) the existence of every particle depends upon the co-operation of the whole mass. Each atom therefore has its own peculiar form and constitution prescribed, by which it is fitted to perform its relative part in the general economy. The number of organs, the form, and proportionate developement of each, are arranged in the strictest harmony: and the whole individual resembles, in the variety and adaptation of its parts, the contrivances of artificial machinery. The inspection of a single piece, unassisted by previous knowledge, will not afford a more adequate notion of the whole organization, than a single brick of the architecture and internal arrangement of a temple or a fortress.* Thus the division of a block of marble yields only smaller masses of the same carbonate of lime, which constituted the whole; while the dissection of an animal or a plant exhibits many different organs: muscle, nerves, and bones, wood, leaves, and flowers.

The labour of analysis has therefore a different termination in organic and in unorganized subjects. The primitive foundations of organic arrangements are to be sought in the simplest structures by which function is performed. Beyond this point, decomposition exhibits merely the inorganic elements; for it cannot be further pursued without the destruction of every property which marks the organic character. Where dissection ends, chemical analysis commences.

The physical tendencies of the elements, though controlled and modified in organic combinations, still subsist in all their vigour and potentiality. In some instances they even conspire in producing the phenomena of life; as when the elasticity of the blood-vessels contributes to maintaining the circulation of the blood. Whenever, by any cause, the functional movements abate in vigour, those physical forces, which have been overpowered and thrown into abeyance, are ready to re-assume their influence, to dissolve the organic combinations, and to substitute others more congenial to the inherent qualities of the elements. A familiar instance of this law is found in the swelling which occurs towards evening in the feet of debilitated subjects. In this case the force of function is insufficient to overcome the opposition, which the gravity of the fluids opposes to their return towards the heart; and they consequently accumulate in the most dependent part of the body. In fevers, accompanied by exhaustion, the vital actions being deranged, the elective attractions of the elementary matter partially overcome the functional forces; and a step is taken towards disorganization, and which is manifested in the putrescent quality of all the fluids. Thus there is in all living compounds a constant tendency towards dissolution; which upon the suspension of function, operates the destruction of the individual, with a rapidity proportionate to the difference between the organic and the physical combinations of its constituent elements.* The re-assumed influence of the physical forces, in matter which has possessed life, constitutes the several species of *fermentation.* All substances capable of undergoing this process having been produced by the operation of living energies.†

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* These simple facts, in the usual mysterious language of Kant, are thus reduced by him to a general proposition: "The reason of the mode of existence of each part of an organized being resides in the whole; while in unorganized matter, the reason of the existence of each part is to be found in itself.

The origin of living function is enveloped in inextricable mystery. The existence of organized matter depending upon function, and function reciprocally requiring organized arrangements, they exhibit a circle unmarked by commencement or termination. The earliest philosophers imagined, that at the commencement of the world, the plastic power of nature was (in its freshness) sufficient to produce organic combinations, by the direct action of the elements; and a remnant of this vigour was believed to exist in the supposed spontaneous formation of maggots and other insects.‡

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* Bones, which contain a large portion of a mineral substance, and subsist to a great degree in virtue of chemical affinities, are much more durable after death than the soft parts of animals.

† The spontaneous decomposition of animal matter is, in common language, termed *putrefaction*; in the technical phraseology of chemistry it is called putrid fermentation.

‡ Sive recens tellus seductaque super ab alto
Æthere, cognati retinebat semina cœli.

And again: *Ov. Metam. I.* 80.

Cætera diversis tellus animalia formis
Sponte suâ peperit. *Ibid.* 416.

The experiments of Redi, an Italian philosopher, having demonstrated the fallacy of the illustration, the inference also fell into discredit. But as the existence of any combination implies the sufficiency of its causes, it still appears reasonable to refer the commencement of living species to some other physical aspect of nature than that which at present it exhibits. It is a curious coincidence, which at first sight appears to bear upon this question, that almost all nations have preserved a traditional notion of some condition of the globe, more favourable to its productions, than that which now exists. But this extraordinary agreement is perhaps more justly explained, as an attempt to account for the origin of evil, than as a result of preserved recollections.

Every day's experience more forcibly demonstrates that the first attempts at unravelling that incomprehensible mystery have in all nations been the same ; and have every where led to a more or less open system of manicheism, in which the good spirit is supposed to have made the world perfect, while an envious evil principle is imagined to have interfered, and to have marred and suspended the benevolent intentions of his antagonist.*

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* Εἰ γὰρ οὐθὲν ἀναιτίως πέφυκε γενεσθαι, αἰτίαν δὲ κακου τ᾽ἀγαθὸν οὐκ ἂν παράσχοι, δεῖ γένεσιν ἰδίαν καὶ ἀρχην, ὥσπερ ἀγαθου, καὶ κακου τὴν φύσιν ἔχειν.

Plutarch de Iside et Osiride.

᾽Ου μιᾷ ψυχῇ φησὶ κινεῖσθαι τὸν κόσμον, αλλὰ πλειοσιν ἴσως, δυοῖν δὲ πάντως οὐκ ἐλάττοισιν. ὅθεν τὴν μὲν ἀγαθουργὸν εἶναι, τὴν δὲ ἐναντίαν ταύτῃ, καὶ των εναντίων δημιουργὸν.

Ibid.

More certain proof of physical change may be deduced from the general appearance of the earth, and from the fossil remains of animals no longer found alive upon its surface. The relations of these animals with nature must be presumed to have been so far altered by some revolution the globe has undergone, as to render their longer continuance an impossibility.

Whether, in the existing state of things, equivocal generation, or the spontaneous combination of the elements in organic forms, be in any case possible, is a question that admits of some doubt; as far as direct observation has extended, living organisations have uniformly been found to originate in germs, produced within the economy of other similar individuals previously existing. But there are many species, concerning whose production nothing positive is known; either their extreme minuteness, or the circumstances under which they are developed, precluding experimental investigation. The infusorial miscroscopic animals, the plant which discolours stagnant water, the vegetation termed *mouldiness*, hydatids,* and other animalculæ, developed in diseased structures, or in fluids, the products of human industry, start into existence under conditions, in which the supposed presence of germs is attended with manifold difficulties.* The maxim of *omne animal ab ovo* is undoubtedly founded upon a very general analogy; but it is perhaps more deeply rooted in certain other doctrines, to which interest and passion have given inveteracy. Between these opinions there is no *necessary* connection; but were it otherwise, the supposed consequences of an opinion form the feeblest arguments that can be opposed against its probability. In the present state of knowledge, therefore, the question cannot be considered as perfectly at rest.

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* Hydatids are small animals of a vesicular form, arranged by Cuvier among the tape worms. They are generated *in the very substance* of different viscera of men and the higher animals. They are frequently found in the brain of sheep; in which situation they cause vertigo, speedily followed by

Dismissing, however, these cases of apparent exception, the great majority of animal and of

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death. If these and similar parasitical animals are the products of germs swallowed with the food, and deposited by the circulating fluids, they must either be capable of an independent existence, or their germs must have been preceded in the order of creation by those of the animals in which they were destined to be developed.

* "On peut observer seulement que les personnes, qui veulent que, sans germe, il ne puisse y avoir de génération, doivent, en même tems, établir, que ceux de toutes les espèces possibles, sont répandus par tout, dans la nature, attendant les circonstances propres à les developper: ce que n'est au fond qu'une autre manière de dire, que toutes les parties de la matière sont susceptibles de tous les modes d'organisation. —*Cabanis Rapport*. v. 2, p. 241.

vegetable species derive their functional power, and receive their earliest organisation from the living energy of a parent. Seeds, eggs, and germs, at the earliest periods in which they can be examined, are already alive. The series of functions destined to complete their structure has begun, and nothing further can be discovered than a continuity of action, which has proceeded from parent to offspring, from the commencement of the existing order of things.

Upon this fact depends a striking difference between unorganised and organic compounds. While the formation of substances of the former class is varied by every slight alteration in the combination of their elements, while the varieties pass into each other by shades, almost insensible, the species of organised beings are rigidly limited to the actual number of parent stocks already in existence; and they are separated from each other by striking differences, permanent and unalterable, through an endless succession of generations. This peculiar condition of organised existences is an immediate consequence of the strong tendency which impels their constituent elements to form certain binary inorganic compounds, preferably to those ternary and quaternary* assemblages, which constitute animal and vegetable matter; a tendency which living action is employed to overcome. The same cause also operates in circumscribing the duration and inducing the dissolution of organic combinations.

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* Vegetable matter is for the most part a ternary compound

The forces which determine the formation of an inorganic compound are at the same time sufficient for its preservation and permanence, and its duration is alone limited by the intervention of new elements. A mass of chalk, kept in seclusion from external agency, would preserve its nature unchanged *ad infinitum*. But if another substance, capable of influencing its constituent ingredients, (lime and carbonic acid,) be brought into contact with it, (say the sulphuric acid,) a new arrangement would take place; the individuality of the chalk would be destroyed, and a new species (plaister of Paris) would result from the combination of the sulphuric acid with the lime; while carbonic acid would be set free, and by escaping from the sphere of action, would acquire a separate and

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of hydrogen, oxygen, and carbon. In animal substances there exists, also, more or less of a fourth element, azote, or nitrogen. Other substances are occasionally present in these compounds, such as sulphur, phosphorus, &c.; but their office is local, and perhaps, in some instances even accidental. They may, therefore, be, to a certain degree, disregarded in general reasonings.

individual existence. Organic combination, on the contrary, being supported by continuity of action, is liable to cease, by the operation of every cause capable of suspending function. The duration of the individual (all accident apart) is proportioned to the wear and tear of the machine; and to the durability of its internal mechanism; so that there is an average longevity assignable to every species, necessarily resulting from its peculiar constitution; and the succession of generations proceeds as regularly as the planetary movements by which their continuance is measured.

The precise nature of the impulses, which the living functions give to the elements subjected to their influence, is wholly unknown. In the most general point of view, they may be considered as consisting in a double series of movements; the one operating an attraction of foreign matter into the substance of the individual, and the conversion of it into a nature analogous to that of the attracting body; the other effecting a repulsion of such parts of its own substance, as, having performed their limited revolution in the economy, have lost their adaptation to their place and office.

The necessity for the attraction of fresh matter into the sphere of organic action is two-fold. First, the elements being, by a definite action, forced into combinations which may be deemed unnatural; they are, by the continuance of that action, hurried forward beyond the point which adapts them to living function, and are thus rendered useless in the economy. Secondly, the actual performance of function is itself accompanied by a waste of substance, which exhausts the frame.

The necessity for the elimination of effete matter arises out of the chemical derangement its presence might produce, as well as from the mechanical hindrance it might afford to the movements of the rest of the machine. To the production of these two ends the entire organisation is more or less immediately subservient; the whole being so harmonized as to place each species in that precise relation to surrounding nature, which insures the accomplishment of the object in view.

From the brief review that has been taken of the distinguishing characteristics of organic and unorganized matter, it is evident that origin by birth, termination by death, organic structure and internal movements, are accidents necessarily flowing from the physical properties of the elements of which animals and vegetables are constructed. The chemical compounds, which we denominate flesh, wood, &c., could not subsist *in rerum naturá*, but through the intervention of living action; nor could the functions discharged by the existing sentient and irritable beings subsist, unless they were composed of the precise materials and arrangements which they actually exhibit.

The processes of assimilation and of elimination, though so widely differing in their object, are conducted by a mechanism extremely similar. Assimilation is, for the most part, performed by the living energy of the solids, exerted upon substances, either fluid, or rendered fluid by the living energy. For this purpose the organic arrangement is essentially vascular, or composed of tubes, in which the elaborated fluids are contained. These vessels are arranged in systems, more complex, as the organic functions are more numerous and extensive. Considered in their totality, they arise from certain surfaces, that can be brought into contact with the peculiar food on which the individual subsists, and that possess a power of corroding and rendering it fluid: they terminate in all parts of the substance of the individual, by open orifices; having the power to convert the fluids, each of them, into the specific nature of the viscus, in which they severally reside.

Elimination is equally performed by vessels, which arise by open orifices, from every point in the substance, and on the surface of the different organs. Their termination varies considerably, in the different systems of organization. In the higher classes of animals, in which they are best demonstrated, they unite to form a common trunk, which pours its contents back into the circulating system; and the ultimate exclusion of the effete matter is proformed by peculiar organs, termed glands, constructed for that specific purpose. The intimate nature of the changes, by which these processes are effected, is involved in the deepest obscurity. No visible difference of structure exists in the ultimate vessels of the different organs, to explain the causes, by which bone is deposited, in one place, in another muscle, in a third nervous matter, &c. &c. The whole is attributed by physiologists to modifications by living action; which however must depend upon structural differences, too minute to be followed by the human senses.

The simplest and most general idea of organization is then that of an assemblage of tubes, commencing upon an assimilating surface, and terminating by an innumerable multitude of orifices, having power to form matter analogous to that of the different organs they supply; and of a second series, beginning from all parts of the organic being by orifices capable of corroding and dissolving its several substances;

and terminating in some system, from which the matter so corroded, is eliminated. This general idea requires very many important modifications and extensions, to adapt it to the peculiar case of each different organization ; modifications, which can only be examined in succession, and which are not essential to the present subject of enquiry.

All substances are not indifferently adapted to the business of assimilation ; each species of animal and plant is nourished by food rendered analogous to it, by a peculiar constitution. It is a necessary condition that the food should contain one or more of the four elements, carbon, hydrogen, oxygen, and azote, which conspire to produce animal and vegetable forms. The earths and metals therefore are totally incapable of becoming organized.

The food is rarely, if ever, so entirely analogous to the substance of the species to which it affords nourishment, as to be adapted to immediate incorporation ; but requires certain intermediate processes, by which its actual combination is broken up, and its elements disposed according to another arrangement. In the simpler forms of organization, and especially in the vegetable kingdom, these processes are few ; but in proportion as the elementary constitution is complex, they become numerous and varied: in man and the higher animals, they include digestion, sanguification, circulation, respiration, and nutrition.

A substance, in order to be susceptible of these processes, must not only contain the elements of organic matter, but must hold them in combination, by affinities less energetic than the digestive powers of the individual to which they are to be assimilated. Vegetables are to a considerable degree capable of deriving support from certain inorganic substances: but animals can alone be maintained by food, that has already been organized; some species even require that it should have received the last degree of organization, and have previously formed parts of other animals.

The great chain of created beings does not therefore co-exist by an absolute, but by a proportionate, harmony; the existence and happiness of some individuals being thus rendered incompatible with that of others. The cruelty of this arrangement, so difficult to explain under any dispensation,* is a consequence, like the other accidents of organization, of the chemical properties of certain substances, and of their relations to the living forces, of which given animated arrangements are susceptible. It is a physical necessity, connected with the most general laws of matter, and forms an inevitable part of the whole system of things, embraced by the term nature.

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* It is however manifest that no more is lost than is gained, and that what is evil to the sufferer, is positive good to the inflictor. Still, every sentient being is in itself an whole, and may justly stigmatize as evil all arrangements hostile to its own well being.

The assimilating and eliminating functions being the supplements to chemical attraction, they prevail in the different organized structures in proportion to the delicacy of their elementary constitution. The flesh of red blooded animals is the most elaborated product of organization; and the intensity of their vital force is at the same time the greatest. In descending through the scale of beings, to the simplest vegetable forms, every modification of sensibility is accompanied by a corresponding alteration in structure, more nearly approaching towards the chemical arrangements of the same elements. At the lowest point of the scale, the exertion of vital force is so trifling, that it is rather credited on analogy, than acknowledged by the senses.

Between the assimilating and eliminating forces there is uniformly a definite proportion, which is alone compatible with healthy existence. This proportion, however, differs widely in the different stages of life. In youth the assimilating powers predominate; the sphere of their activity exceeds the dimensions of the body, which extends itself in every direction under their impulse. In middle life, assimilation and elimination are more nearly equipoised, but still the balance is in favour of the former; as is evinced in the lateral developement of the body, the squareness of frame and corpulence, incidental to that period. In old age the eliminating forces acquire the ascendency, as is indicated by the shrivelled skin, and extenuated muscles of the "lean and slippered pantaloon."

His youthful hose well saved, a world too wide
For his shrunk shanks.

The internal organs are not more exempt from this law than the rest of the body; even the bones diminish in volume, and the brain itself becomes smaller as life advances; a circumstance to which unquestionably must be attributed the diminished powers of thought, and oblivion of past events, the still more unlovely attributes of senility and decrepitude.*

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* The stoics in treating of age have fallen into the same mistake which vitiates their discussions on evil in general; they have denied that it is an ill. With respect to the sum total of nature there can be nothing evil, because, in itself *totus teres atque rotundus,* it is unsusceptible of injury. In this sense "*nihil potest malum videri, quod naturæ*

The intensity of the assimilating and eliminating forces may in some degree be measured by the rapidity of their processes. The organic movements are most rapid in the earliest periods of existence; and they slacken as life advances, in a degree, less than preportionate to the arithmetical increase of age. The sudden burst of vegetation which distinguishes the spring of the year is an instance of this law; for the leaves and flowers of perennial vegetables are new individuals, having an independent life; and they are in all respects, strictly analogous to the entire plant of the several annual species.

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necessitas afferat. But man being a combination perishable, and susceptible of external influence, is placed in many circumstances unfavourable to his permanence, and with respect to himself positively evil. In this category old age is deservedly placed; it is generally disease, it is always privation and feebleness; and thus far, *malum in se.* But though wrong in their use of language, the stoics must ever be admired for their elevated views of man's nature, and for their constancy in warring against the chances and misfortunes of humanity. The inutility of lamentation over the lapse of life should silence the reasonable man; its impiety should awe the religious; "*quid enim est aliud gigantum modo bellare cum diis nisi naturæ repugnare.*" But above all, the progressive alteration in the feelings, which accompanies the decline of life will prepare the mind for parting with a gift no longer serviceable to its possessor, if unavailing regrets for lost opportunities, or extravagant designs for the future, do not preserve the intellect in a preternatural state of agitation.

Organic existence being maintained by the successive deposit of new elements, and the removal of their original substance, the material identity must in a certain time be totally destroyed. Various opinions have been entertained respecting the precise period necessary for effecting this change in the human body ; and different data have been adopted in forming these estimates.

The ratio of the daily supply of food to the whole weight of the body is a ground of argument eminently fallacious: since it is impossible to appreciate the proportion of food consumed in the discharge of function, or eliminated as unfit for the purposes of assimilation.

Another datum, equally unsafe, is the time required for the healing of wounds, and the exfoliation, or separation of scales of dead bone from the surrounding healthy mass. For this time is by no means the same under circumstances apparently similar.

A very common opinion supposes a complete revolution of the whole man in about forty days. But as every organ differs in structure, so it varies in functional force, and in rapidity of decomposition and renovation. Bone possesses one degree of energy, muscle another, membrane a third ; and the revolutions of each must be governed by their own peculiar laws. In general the movements of a part are slow, in proportion to the condensation of its substance;* and it is not improbable that in parts of highly developed vitality, and of fluid constitution, there may be an incessant flux of matter, which prevents any particle from remaining for a length of time in the same situation, and hurries it forward through the eliminating system, immediately after its deposition by a nutrient vessel. In this case, the same particle must perform many offices in the system, and submit to many successive changes before it is fitted for the purpose of excretion: and a greater degree of probability attaches to this view from its striking coincidence with the known œconomy of means, and variety of resources presented in all the wonderous and almost infinite operations of nature.

It may be asked whether vitality, in any case, subsists in total independence of vital motion; or to use another phrase, whether life can exert itself otherwise than by change. The eggs of animals and vegetable seeds may be made to germinate at the end of very long periods of apparent inaction. If soil be taken up at various depths from the surface and exposed to the air, the different specimens will not unfrequently exhibit each its own peculiar crop of weeds. The seeds of these plants must have remained buried from the very remote æras of the formation of the successive strata, and this fact should seem to answer the question in the affirmative. But it would be difficult to determine whether the permanence of these forms is a consequence of their organization, or depends solely on chemical affinity; that is, whether life in this instance is continuous, or exists merely as a contingent potentiality. In the absence of experiment, it may be stated that analogical reasoning is in favour of the latter alternative. Life is known exclusively by function; function implies movement; movement change; and change dissolution. To this must be added, that vegetable seeds, when preserved from the influence of air and moisture, are forms but little liable to decay, and may well be supposed to owe their durability entirely to their chemical constitution.

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* This proposition must be admitted with considerable restrictions. Hybernation is a phenomenon affording a remarkable exception to it.

Assimilation and elimination, the conditions of organic existence, are the great end to which all the faculties and functions of the most complex living beings refer. To their accomplishment are adapted the various organization of limb, the diversified power of sense, the certainty of instinct, the aberration of passion. In the attractive force of assimilation may be placed the physical basis of self-love; and even the continuation of species is grafted upon it by the connecting medium of pleasurable sensation. Organized beings, therefore, must be considered as *foci*,* into which the surrounding elements are for a while attracted, and forced to enter into peculiar combinations, in order to perform a temporary part in the œconomy of life; and from which they are then eliminated and thrown off. That which the animated being was yesterday it ceases to be to day. The materials of which it is compacted, like the waters of a river,* are passing in incessant flux. The organization itself submits to a progressive, but inevitable alteration; and the moral constitution varies with the physical structure. Passions arise, tyrannize, subside, and disappear; and the governing principle changes with the successive development of particular organs. In what then does the identity of such beings consist? not in sameness of substance, not in continuity of function; for if so, the parent and offspring would be identified; not in continuity of perception, for perception is not an universal attribute of organic existence. Identity can alone be traced in those trains of acquired action, which, arising in every moment of passed existence, influence to a greater or less extent, the mode of being in all that succeeds.

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* Cuvier Leçons d'Anatomie Comparée.

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* "Nous sommes réellement, physiquement comme un fleuve, dont tous les eaux coulent dans un flux perpetuel. C'est le même fleuve par son lit, ses rives, sa source, son embouchure, par tout *ce qui n'cst pas lui*; mais changeant à tout moment son eau, qui constitue son être. Il n'y a nulle identité, nulle mêmeté pour ce fleuve."

Dict. Philos. Article Identité.

The comparison of human life to the flow of a stream forms a favorite image with the poets of all countries.

The functions of *nutrition* (a term which may conveniently be adopted to embrace both assimilation and elimination), together with those subservient to the reproduction of species, include all the phenomena necessarily connected with the idea of life, and comprise all that can be properly attributed to vegetable existence.

Perception has indeed been assigned to plants by some fanciful writers, in compliance with notions more poetic than philosophical.* But this faculty is intimately connected with that of loco-motion, to which alone it is subservient. Without perception there could be no volition, and the organs of loco-motion could not be thrown into concatenated action. Without the power of avoiding pain, and of seeking pleasure, sensibility to external impressions would form a condition too miserable to be permanent. Such a condition the poet has well described as a sepulchre rather than a body :—

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* See Smith's intoduction to Botany, p. 3, the works of Darwin, &c. The facts upon which this notion is founded are various and beautiful. The roots of trees, in approaching the foundations of a wall or rock which they cannot penetrate, turn aside at a short distance before they arrive at the obstacle. If a tree stand by the side of a ditch, the roots will not pursue their usual horizontal course so as to become exposed; but they suddenly dip down perpendicularly on approaching the bank, until they get below the bottom of the ditch, when they resume their natural horizontal tendency. The phenomena of the sensitive plant, of the Hedysarum gyrans, and of the Dionæa muscicapa have likewise contributed to the supposition of vegetable perception. The leaves of the last plant are beset with thorns, and their surface secretes a sweet liquor very attractive to flies. At the instant when an insect touches the surface of this treacherous apparatus, the two lobes of the leaf approximate, and the thorns, crossing each other, pierce the unfortunate animal, in a manner analogous to that execrable engine

> ———Ne sol qui spirito umano
> Albergo in questa pianta rozza et dura,
> Ma ciascun altro ancor. Franco o Pagano,
> Che lassi i membri a piè dell' alte mura,
> Astretto e qui, da nuovo incanto e strano,
> Non so s'io dica in corpo ò in Sepoltura.
> Sono di sensi animati i rami ed i tronchi,
> E mecidial sei tu, se legno tronchi.*

This dispute, like many others, is perhaps merely verbal, and dependent upon the greater or less degree of latitude attached to the word per-

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of selfishness and cupidity—the man-trap. The Drossera, longifolia, and rotundifolia present a similar mechanism.

* Nor yet alone my spirit is confined
Pent up within this hard and rugged rind;
But ev'ry wretch, in hapless fight who falls,
Pagan or Frank, by Solyma's high walls,
Here fixed must find (to magic arts a slave)
A tree his body, or his living grave—
Each branch alive to injury and pain,
Who fells our trunk will slay us o'er again.
Tasso Ger. lib. l. xiii. 43.

ception; a term which, in the progress of the present work, must be accurately defined. Few will be inclined to concede to the vegetable tribes sentient powers, approaching to those of animals; and for the rest, the distinction regards rather our own modes of consideration, than the affections of the subjects themselves.

The nutritive functions are carried on entirely within the body of the individual. They are connected with each other in an unbroken series; forming a circle of actions, independent of the external world, except in as far as they derive from it the materials on which they operate. The functions of sense and loco-motion are altogether occupied with external existences,* with which they maintain a varied and most extensive connection, Every object in nature is capable of administering to them the occasions of their actions; of exciting an idea or of determining a motion. They have been therefore happily described as *functions of relation.*

The functions of relation and those of nutrition, though they form together one whole, connected in action and in end, may yet be advantageously considered apart, and as if independent. The laws which govern their respective movements are in many particulars different, and this species of analysis leads to some important and striking conclusions.

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* The sensations of pain which arise within the body may be considered as proceeding from external causes; such causes being really so with respect to the nervous system, which constitutes more immediately the "*moi*" of the individual.

The functions of relation are the products of a living force, greatly superior to that which presides over the performance of the nutritive actions; the organs by which they are executed are more complicated, their movements have greater latitude and rapidity, and their substance is the product of affinities more delicate, more distantly removed from those of merely chemical origin, and the least susceptible of a permanent durability.

Permanence of substance and tenacity of life are for the most part in the inverse proportion to the complexity of structure and of elementary constitution. The lower animals are more tenacious of vitality than those in which the nervous system is distinctly developed.

In proportion as this system is more perfect, as the vascular, respiratory, and digestive apparatus are more complete, the animal is exposed to derangement from a greater variety of accidental causes. If, therefore, the development of intellect had not kept pace with the structural complexity, and thus furnished a principle of counteraction proportionate to the increase of danger, man and the higher animals, instead of commanding upon the face of the earth, would have been the first species in the system of nature to disappear from its surface.

The greater part of every vegetable consists of an elementary substance (carbon) which, under the ordinary temperature, and other physical circumstances of the atmosphere, is not prone to enter into new combinations: such structures are but little liable to change. The oak timber used in some of the most remarkable British edifices has resisted the decomposing efforts of air and moisture for many centuries.

The comparative simplicity of the elementary constitution of vegetables is also evidence that their arrangements stand in closer relation to the physical properties of their constituents; and are less dependent upon living energy than animal combinations. If some occasional exceptions be disregarded, vegetables admit but of three elements* into their composition; while animal products rarely contain fewer than four. But it is a known law, that chemical affinity is exerted with greater energy in proportion as substances are presented to each other in smaller numbers: and that the elements are more disposed to form binary than ternary or quaternary compounds. The living force which is necessary to prevent the components of animal matter (nitrogen, hydrogen, carbon and oxygen) from uniting in pairs (so as to form ammonia, water, and carbonic acid), must necessarily be more energetic than that which is requisite for inducing the ternary vegetable compounds of oxygen, carbon and hydrogen, and for suspending their tendencies to binary union.

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* Nature never proceeds *per saltum*. Traces of any given peculiarity, characteristic of a class or order, may always be found in the link immediately preceding it in the great chain of nature; a constant evidence of the inadequacy of scientific systems. Nitrogen or Azote, which may be regarded as the peculiar element of animalization, exists also as a constituent of some vegetables; more particularly in the acrid cruciform plants. But it is never present in proportions large enough to materially affect the general proposition here advanced.

To this nearer analogy between vegetable and chemical combination may be traced the power which plants possess of deriving nourishment from unorganized matter; a power, which at once determines their place in the scale of beings, by rendering them independent of loco-motion. The materials of vegetable nutriment (carbonic acid and water) are diffused almost universally over the globe, and are brought into contact with the plant, whatever may be its position. Suspended in clouds, and borne along in streams, these substances are conducted, by the agency of winds, and the inequality of the earth's surface, through every region; diffusing life and verdure alike to the Alpine height and to the imbosomed valley.*

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* In situations inaccessible to an abundant supply of water, a few plants still subsist by means of a peculiarity of structure, which enables them to attract and to retain the small portions of moisture dissolved in the burning atmosphere. The majority of plants which are found in the sandy desarts of Africa are of a cellular structure, and contain much water in their interstices.

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Animals, on the contrary, requiring nourishment already organized, in order that it may be susceptible of assimilation with their more delicate constitutions, can obtain support only by active exertions ; and pleasure and pain are opened to them as the main-springs of those actions, without which they must perish. Placed by this necessity in relation with whatsoever exists on the surface of the globe, they require skill, force, and agility, in various degrees, to supply the means of life, and to avoid the dangers which environ it. Hence the subordinate organs in all their endless variety ; the wing, the fin, the hoof, and all the diversity of weapons with which nature has armed the least as well as the greatest of her creatures.

The numerous and energetic actions which these instruments perform, imply a corresponding developement of vital force. They originate also a complication and extension of the nutritive processes ; since the relative organs themselves must be nourished, and for that purpose demand matter of a constitution considerably more recondite, than is requisite for parts of a lower vitality. The existence of the relative functions is, on this account,

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" The Tillandsia, or Wild Pine, of the West Indies, has every leaf terminated near the stalk with a hollow bucket, which contains from half a pint to a quart of water. Dr. Sloane mentions one kind of Aloe furnished with leaves, which, like the Wild Pine and Banana, hold water. Nepenthes has a bucket for the same purpose at the end of every leaf."

Darwin's Loves of the Plants, Canto I. l. 367—*note.*

incompatible with that simplicity of nutritive organs which is remarked in the vegetable tribes. The vast extent to which this necessity for seeking the materials of nourishment influences the character and vitality of animals, is not imperfectly illustrated by that class of beings termed Zoophytes. Connected with the other animal tribes by their demand for organized food, the Zoophytes are, like them, provided with stomachs; they have also in some instances prehensile instruments for carrying nourishment to their mouth: but inhabiting the waters, they receive the food as it is brought to them by the current and by the tide, and thus to a great degree they partake of the vegetable character. Like plants, they are, many of them, divested of loco-motive powers, remaining fixed to the spot upon which they are produced. Like plants too, they possess neither brain, nor organs of external sense. It is singular also, that the Zoophytes, like vegetables, are propagated by buds, and may be artificially multiplied by a succession of cuttings. A constant and invariable relation may then be traced, not only between the structure of each species and its chemical constitution, but between its functional powers and elementary arrangement. Whatever may be the intimate nature of the vital forces, whether they arise out of unknown energies of the recognized elements, or originate in the presence of an hitherto undiscovered principle, they are still corollaries and consequences of the physical properties of matter. Between the wild and extravagant passions of the social animal and the simple attractions of chemical affinity, the differences are indeed extensive; but in pursuing the great chain of existences link by link, the accessions of moving force are found at each successive step, so trifling, that it is hard to fix the limits at which any new principle of action is introduced. Where the primary causes of all phenomena are unknown, it is vain to form hypothetical principles of action for each. The analogies, which connect the different forms of nature in one entire and perfect whole, are broad and obvious: but the distinctions which the subtilizing genius of man has invented to separate and to isolate, are contradicted and deranged at every new step of successful investigation.

CHAPTER II.

OF ORGANIZATION.

ORGANIZED bodies consist of solid and fluid parts—The relative proportion of these varies in different structures—Their influence in the economy reciprocal—Organic Action, energetic in proportion to the fluid constitution of the subject — Solidification, a result of living action, and necessary cause of death — Primordial Fibre, a theoretic notion —Tissues, the simplest cognizable organic forms—Cellular Tissue the basis of organized structures—Its constitution, secretions, serum, fat—Its Blood-vessels, &c. Nerves—Arrangement of cellular tissue illustrated in the muscular structure—Of the Vascular Tissues, Arteries, Veins, Absorbents, Capillaries —Structure of Vessels—Hydrostatic Law which governs the movements of the fluids in the vascular systems—Proper Tissue of the several organs—Their physical and vital relations to the function of each organ—Combination of Tissues—Comparison of Vegetable and Animal Organization—One System of causation common to both—Of the Fluids—Nutritive and secreted fluids, both formed by the energy of the solids — Blood, its Coagulation—Proximate Principles—Fibrine—Albumen—Gelatine—Saline Ingredients—Red Globules—Constitution of fluid blood — Blood of different animals — Chyle—Lymph—Theory of organic fluids imperfect—Difficulty respecting Azote—Secreted Fluids.

CHAPTER II.

OF ORGANIZATION.

"Fateor equidem ea esse rudia, inchoata, et manca; cujus rei culpa, ut maximam partem in me recidat, partem tamen in ipsius artis conditionem erit rejicienda. Nemo naturæ studiosus nescit in quantis tenebris, etiam brutæ hujus telluris scientia jaceat; et quam parùm adhuc profecerimus, in cognitione rerum inanimatarum. At vero in corporis humani scientia, et eadem omnia, et multa præterea, quæ sint animantium propria, nos latent."

Heberdeni Commentaria, ad finem.

IT is not easy to ascertain with precision the conditions by which a structure becomes capable of enjoying vital powers. Vitality is possessed by beings of very great apparent simplicity; and even in the most complicated animals, there are parts endowed with life, which consist of the most delicate membrane; in some instances, as fine as the airy bubbles blown by children from a pipe.*

As far as observation has hitherto extended, the concurrence of a solid and a fluid seems necessary to vitality. The microscopic animals cease to exhibit signs of life when the fluids they inhabit are dried up, and they recover their living powers upon the return of moisture. The celebrated John Hunter, indeed, taught that the blood is alive, and considered its coagulation as a result of living energy: but if this be the truth,* the vitality is rapidly exhausted, when that fluid is withdrawn from the action of the solids; and no other living species is known of a simply fluid constitution.

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* Bichat.

The proportion which subsists between the solids and fluids in different organizations is considerably various. In the human subject the fluids have been calculated to predominate over the solids, in the ratio of six or even eight to one. In trees, they do not exceed the proportion of three to one.† A similar variation subsists also in the different organs of the same individual. Considerable difference of opinion has been entertained with respect to the relative importance of the solids and fluids in the economy. While the early writers attributed all the phenomena exclusively to the operation of the fluids, the moderns ascribe every thing to the action of the solids. But the influence of these parts is evidently reciprocal. For as the fluids are at once the materials from which the solids are formed, and the stimuli which excite them to action, their integrity is essential to the health of the whole; the solids, on the other hand, by their living energy elaborate and concoct the fluids; and if the former be diseased, they cannot but affect the constitution of the latter, and thus corrupt the very fountains of life.

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* John Hunter, in affirming that the blood is alive, was influenced by his theoretical notion of a materia vitæ diffusa, which matter he believed to be present in the circulating fluid. That the coagulation of the blood is a phenomenon dependent upon vital causes, can scarcely be doubted. There is consequently no great violence done to language, in designating this coagulation as a function, and consequently in attributing life to the fluid itself. The error which is most likely to proceed from this species of nomenclature, is a too ready credence of the reality of a substantive existence corresponding with the term life.

† Richerand.

Rapidity and extent of function increase in proportion as the fluids abound in the natural constitution of the individual. The growing parts of vegetables are very considerably more succulent than the old wood; and the animal structure contains a larger proportion of fluids than that of vegetables. Women and children, whose functions are eminently rapid, have more fluids in their composition than the adult male; whence they derive the characteristic softness, plumpness, and elasticity of their habit.

It is a law of living energy that its exertion is attended with a condensation of the substance of the organ in which it takes place. The earlier therefore a subject be examined, the greater will be the proportion of fluids in its composition. The superior density of particular organs exposed to constant and violent action, the hardness of the palms of labourers, the solidity of the muscles in the arms of smiths, afford marked instances of the operation of this law.

This progressive induration of the solids, though at first it carries the body from feebleness to strength, eventually causes a rigidity of fibre incompatible with the healthy action of the capillaries. At the same time that the nutritive functions are thus obstructed, the nervous fibre is rendered less susceptible of impressions, till at length the movements become embarrassed and are suspended, and the machine is delivered over to the exclusive dominion of physical causes. This event constitutes, what alone can be considered as a natural death, or dissolution, the result of actions essentially healthy. All other modes of decease are more or less the consequence of accident and of extraneous causes. If a living organized being be examined at the epoch of its greatest perfection, when the structure is sufficient to perform the functions, and the functions are adequate to maintain the organization, a mutuality of cause and effect is perceived, which almost promises immortality. But a closer inspection exhibits causes of dissolution in the very actions by which life is supported, and shews that, in the most philosophical sense, " in the midst of life we are in death."

Nascentes morimur, finisque ab origine pendet.

To give an indefinite extension to such combinations is physically impossible. That which is *accidental* may be governed, and that which results from *violence* may be repaired; but whatever is fundamental in the scheme of nature exists by a necessity superior to control, and incapable of alteration.

In thus dissipating the dreams of the alchymist, and in overturning the theories of perfectibility, philosophy, while it dispels a pleasing dream and extinguishes for ever the long indulged hope of sublunary immortality, leaves not the mind void of consolation, nor resigns it to the contemplation of destruction, unarmed against despair. By mankind, in general, death is conceived to be a violence inflicted upon humanity, as the consequence and punishment of transgression; and punishment, by an obvious association, introduces the idea of sufferance. But an acquaintance with nature exhibits dissolution, not less in harmony with the laws of existence, than life itself.* "Mortem a diis immortalibus non esse supplicii causâ constitutam, sed aut necessitatem naturæ; aut laborum ac miseriarum quietem esse."† The same universality of consent, the same general combination of function, which gives hope, vigour, and restless curiosity in the season of youth, reigns equally over the hour of decease, and composing all the feelings in numbness and confusion, fits the mind no less than the body for the impending process. Death thus divested of its adscititious notions of force and infliction, enters among the common functions of our being, and if not viewed with indifference, may be expected with resignation.* †

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* The words of the Emperor Antonine:—οἷον γὰρ ἐστι τὸ νεάσαι καὶ τὸ γηράσαι καὶ τὸ αὐξῆσαι, καὶ τὸ ἀκμάσαι, καὶ ὀδόντας καὶ γένειον καὶ πολιὰς ἐνεγκειν, καὶ σπεῖραι καὶ κυοφορῆσαι καὶ ἀποκυῆσαι καὶ τὰ ἄλλα τὰ φυσικὰ ἐνεργήματὰ, ὅσα ἁι τȣ βίȣ ὧραι φέρουσιν τοιȣ̀το καὶ τὸ διαλυθῆναι.

Lib. 9. τιων εις εαυτον.

† Cicero in Catilin: IV.

On ne peut naitre
Que pour mourir.
De cent maux le trepas delivre.
Qui cherche à vivre,
Cherche à souffrir.

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* The excessive cruelty of capital punishment consists in the necessity it implies of facing death, with every function braced for the healthy and enjoyable continuance of life; and in the want of that analogy between the condition of the mind and the body, which should fit the culprit for the encounter. The same disproportion attends some few diseases. But the death-bed is seldom a scene of conflict or regret.

† As freshness can alone give intensity to impressions, and activity to exertion ; it is a beneficent dispensation that removes man from a scene which, if protracted, must eventually terminate in nauseating satiety and hopeless disgust. Swift's Strulbruggs are an hideous picture of mortal immortality ! Mr. Godwin, in his novel of St. Leon, however, gives a fairer transcript of our idle wishes by uniting the renovation of body with senility of mind ; and this he truly represents as a combination absolutely intolerable. But if the imagination confer a youthful vigour of intellect, emancipated from the blunted impressions of

. . . . Est-on sage
De fuir ce passage ?
C'est un orage
Qui mêne au porte.*

The intimate nature of organisation is a subject of extreme difficulty. It has exercised the patience and exhausted the ingenuity of a multitude of inquirers. The most eminent physiologists of the last ages, deeply imbued with mathematical notions, endeavoured to establish in anatomy, an element, equally simple with the geometric line.† They accordingly imagined the existence of a primordial fibre, which they considered, as the universal basis of organised structures.

Observation has, in no instance, sanctioned this doctrine, by arriving at the hypothetical term of inquiry which it proposes. The last results of dissection exhibit the same complexity of structure, as the aggregate from which they have been abstracted.

In order to arrive at an accurate notion of or-

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experience, as the effect of its arcanum, identity is destroyed, and the supposed renovation of life differs in no respect from that which already subsists by the natural succession of generations.

[*] Quinault. The beauty of these lines must apologize for the triviality of the idea they embody.

[†] Fibra enim physiologo id est quod linea geometræ, ex qua nempe figuræ omnes oriuntur.

Halleri Elementa, t. i. p. 2.

ganisation, it must be remembered, that no particle of living matter can subsist without the coincidence of, at least, two functions; and that many more conspire in the structure of complicated organs. The slightest puncture, made with a needle in the skin, will excite pain, and will draw blood. Upon this speck, therefore, are assembled a nerve and a blood-vessel, besides the nutritive vessels and absorbents necessary to the existence of each. As far as observation, even when assisted by the microscope, has extended, this complexity of structure is still perceptible. Physiologists, therefore, abandoning the unprofitable pursuit of a simple organised element, have preferred to stop short at points upon which the imagination may rest, while the subject is still free from the confusion, incidental to a contemplation of things too minute for the grasp of mental comprehension.

In the anatomy of the larger and more observable structures, it is found that, besides the common parts necessary to growth and subsistence, there is one peculiar substance, which gives to each organ, its particular character, and more expressly fits it for the performance of its appropriate function. Thus, in muscles, besides their arteries, absorbents, nerves, &c., &c., there is a substance which exclusively *contracts;* in the nerves there is a matter, which alone enjoys the power of *conveying impressions.* These several peculiar substances are taken by modern physiologists as the elements of organisation; and are adopted, in their reasonings, as the ultimate terms of inquiry. Their number is necessarily equal to that of the functions, which the individual is capable of enjoying.* To these substances the French have applied the appellation of "*tissues.*"

Though susceptible of an abstracted consideration, the tissues appear to exist only in mutual combination. A simple elementary tissue is, therefore, purely an *ens rationis*, adapted to represent a particular mode of considering the subject; not a form really existing. Its assumption as elementary, or as the last term of organisation, is, nevertheless, perfectly justifiable; since the tissues are the *sedes ipsissimæ* of the living powers, beyond which nothing can be traced by the senses, or conceived by the imagination.

The basis of all animal and vegetable forms is a peculiar tissue, which, from the arrangement it affects, has been termed *cellular.*† It should appear that every distinct molecule of organised matter is inclosed in an envelope of this tissue, which serves at once as its matrix and support. It may, therefore, be regarded as the mould, in which the several organs are cast, and as the scaffold by which they are sustained. The cellular tissue of animals, differs from that of vegetables, chiefly in containing azote or nitrogen among its elements. In arrangement, and in function, the cellular tissue of both classes agree; organisation following one common law, through all the individuals produced by its agency.

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* The merit of this mode of considering the subject, rests with the justly celebrated French anatomist, Bichat. The application he makes of the term *element*, follows strictly the analogy of its chemical employment, which implies no positive assertion.

† The brain has been generally, but most inconceivably, regarded as divested of cellular membrane. The pia mater evidently performs all the functions of this membrane, and is without doubt identical with it. "The pia mater," says John Bell, "is to the brain what the cellular membrane is to the other

The cellular tissue exists in a larger or smaller quantity, in every organized structure. Passing between the several organs and filling their interstices, it restrains them in their proper places, and insulates and protects them from the influence of each other. It enters also into the structure of other tissues, and performs to each particular fibre and vessel the same offices which it fulfils towards the organs; at the same time that it serves as a bond of union, cementing and consolidating the whole.

The cellular substance of animals consists of an assemblage of whitish transparent laminæ, crossed by filaments of a milky lustre. They are

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viscera and parts of the body ...... therefore in my judgment, the pia mater is rightly considered by some anatomists as a cellular substance."

Anat. of Human Body.

so interlaced with each other as to form cells of various shapes, which communicate amongst themselves throughout the whole body. In texture, it is more loose and abundant in the interstices of organs, and more dense and concentrated in their substance. The size of the cells is subject to much variation; their sides being possessed of a considerable degree of contractility and of extensibility.

The surfaces of the cellular tissue are habitually moistened by a vapourous exudation, secreted by its own vessels, which is termed the serous fluid. The cellular substance is also the exclusive seat of the secretion called *fat.*

When distended with either of these substances the cells are capable of assuming a size double, treble, or quadruple that which they exhibit when empty. The cellular substance thus becomes the seat of that increase in the volume of the body, which constitutes "*l'embonpoint.*" For in the fattest person and the most lean (provided there be no positive emaciation), the nervous and muscular structures are, cæteris paribus, of nearly the same dimensions.

The free communication, subsisting between the cells of this tissue, is manifested by a variety of circumstances; the too abundant serum, universally effused from the whole cellular tissue in dropsy, shifts its situation with every change in the position of the body; and accumulates in those parts, which happen to be most dependent.

After a long maintenance of the horizontal position, it is more equally diffused over the whole body; when it causes that puffiness of the face, which dropsical patients exhibit, before they leave their bed. Towards night however it will have totally deserted the upper half of the body, and percolating the cellular tissue, become collected in the legs and thighs, which it distends to an enormous bulk.

The permeability of the cellular structure is likewise proved by the facility, with which the dropsical fluid, may be drained off, from a few slight punctures made in the skin. Of this property butchers avail themselves to give a false appearance of plumpness to their meat, by injecting the tissue with air; and beggars have been known to adopt the same means of giving to their persons the semblance of disease, in order to extort alms, from the credulous and the ignorant.

The mechanical permeability of the cellular tissue is closely modified by the living energy. After death all the fluids find their way indiscriminately towards the lowest part of the body; and give to them a mottled and bruised appearance, which by the inexperienced might be mistaken for marks of violence. During life however the cellular substance is totally impervious to any other of the natural fluids, except the serous secretion; nor indeed does this liquid appear to find a ready passage, except when the vitality is somewhat exhausted, or when under the pressure of disease.

The fat is not equally diffused over all parts of the body, but is principally accumulated under the skin, in the interstitial tissue of organs, requiring much latitude of motion, and around certain of the abdominal viscera. The subcutaneous fat greatly contributes to the beauty of countenance, by softening down the harsh lines, produced in the face, by the play of the muscles ; and by giving a smooth, plump surface to the skin. For this purpose however, the accumulation must not be excessive; least, by a disproportionate distention of the cellular tissue, it overwhelm and bury the muscles, obscuring their action and destroying expression.

It is in this particular, that the voluptuous and indolent life, which the females of the upper classes of society lead, contributes to the preservation of their personal appearance ; the accumulation of subcutaneous fat, preventing the subsidence of the skin into wrinkles; while the softness and pliability of the frame, which the same causes produce, retard the ills of age, and to the faculty of pleasing, add a protracted capability, for enjoying the pleasures of social existence. There is, indeed, no cant more absurd than that, which is daily advanced respecting the advantages of poverty, and the worthlessness of riches.

Wealth is power, and like all other forces, it is ill, only when abused. Poverty on the contrary, is perpetual childhood, ignorance and imbecility: the last cold comfort, which attends the extremity of misery, embraces all its advantages;

Qui procumbit humi, non habet unde cadat.

The minute structure of the cellular tissue, is not less obscure than that of the other organizations. The laminæ probably consist in little more than expansions of nutritive vessels, which appear to be collected into bundles to form the filaments that cross them. In its healthy state, this tissue exhibits scarcely any traces of vessels; but when inflamed, its vascular nature is rendered manifest, by the distention of the capillaries with blood; when from their number and delicacy, they cause the surface to assume an uniform red colour. The existence of nerves has not yet been discovered in this substance; but whether this proceeds from the absence of these organs, or depends upon their being concealed by the general whiteness of the mass, cannot safely be decided. When unaffected by disease, the cellular tissue exhibits few tokens of sensibility; it may be lacerated, or irritated by chemical stimuli, without exciting pain. Its vitality is the same, whether seated in an organ, or existing in its interstices; and has nothing in common with the part to which it belongs. It neither feels in a nerve, contracts in a muscle, nor secretes in a gland. When inflamed, its sensibility is inordinately exalted; as almost every one has experienced, during the suppuration of a boil.

The cellular substance, forming the matrix of the whole body, is the most universal of the tissues, which contribute to organization. Each particular organ may be considered as a reticulation of this substance; which determines its outline and size, and contains in each of its separate and most minute cells, a particle of the appropriate substance, that gives character and utility to the part. In the earliest examinable state of fœtal existence, the embrio consists of an uniform mass of cellular tissue, deluged with fluids: at later and later periods, the organization is more completely distinguishable, the other tissues are more extensively developed, and the cellular substance loses much of its apparent predominance.

In the seemingly homogeneous mass, which is first observed, it is difficult to conceive or explain the local variations of vitality, which must precede the formation of the different organs. But in science the hardest though the most necessary task to learn, is that which teaches the feebleness of human powers of investigation. At every turn Isis presents her veiled countenance to the baffled eye of curiosity, and points to the humiliating sentence:—

ΤΟΝ ΕΜΟΝ ΠΕΠΛΟΝ ΟΥΔΕΙΣ ΠΩ ΘΝΗΤΟΣ ΑΠΕΚΑΛΥΨΕΝ*.

In the structure of the muscles, which, from the latitude of their motions, require a looser arrangement of substance, the disposition of the cellular tissue is the most clearly discoverable. In these organs, the smallest observable fibre is enveloped in a thin cellular tissue, which unites it to other fibres of the same substance. In this manner, several bundles of fibres being collected, are included in a somewhat larger quantity of cellular tissue, by which they are in a similar order united to corresponding fasciculi. By an ascending series of these aggregates, the whole organ is completed; when it is inclosed in a more substantial envelope of the same cellular tissue, which forms a decided separation between it and other parts.

Along the interstices, which the cellular substance thus forms, are distributed the arteries, veins, nerves and absorbents; which branch off as they proceed to follow the minuter subdivisions, formed by the cellular tissue, so as to provide every particle with its own vessels and nerves.

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* Plutarch de Iside et Osiride

Ea fere hominum est infelicitas ut omnis ultima rerum physicarum historia parum firma sit, et ut altera illa, rerum gestarum memoratrix, in mythicos fines terminetur.

Halleri Elementa, t. ii. p. 176.

This arrangement, which is more or less applicable to all animated structures, gives to them their common character of organization. The several forms, size, density, colour, and other distinguishing features of each organ, arise either out of the nature of its appropriate substance, or the mechanical or physiological relations it bears to the rest of the economy.

Thus, for the reasons already given, the structure of muscles is more loose and flexible than that of bones or even glands. The redness of their colour proceeds from the rapid consumption of vitality, attendant on the discharge of their functions, and their consequently abundant supply of blood. The pulpy softness of the brain, in like manner, is connected with the delicacy of its functions; and its whiteness arises from the minute sub-division of the blood-vessels, by which its structure is maintained, and which prevents the too forcible impetus of the red blood into the tender substance of the organ. Organized structures are essentially vascular; the nutritive fluids by which their substance is supported, being contained universally in tubes, by the living energy of whose inner surfaces their qualities appear to be maintained and regulated. The form and distribution of the several systems of vessels are adapted to the nature and habits of the species ; in such a manner as that every particle receives an ample supply for its support. In the higher species of animals the vascular systems resemble, in their outline, a tree, with its trunk, stem, and branches. They consist of the *arteries*, which circulate that portion of the blood which has undergone the action of the air ; the *veins*, which contain the sanguine fluid, before it has been so influenced ; and the *absorbents*, which propel a fluid, formed from the general *debris* of the whole body. The capillary nutritive vessels, by which the substance of parts is supported, are branches of the arterial system; and the absorbents may be considered as a branch of the veinous apparatus. A question indeed subsists among physiologists whether absorption may not also be performed by the veins themselves. Many circumstances seem to give a sort of probability to this theory; and it has been adopted to explain the rapid transmission of the fluid ingesta from the stomach. The difficulties on the other hand which attend this view of absorption are many ; and the facts by which it is supported, far from conclusive. Above all it may be doubted whether the veins could possess an absorbent power, without fatally endangering the œconomy, by the abrupt admixture of foreign substances with the circulating fluids.

The most simple notion which can be formed of a vessel, is that of a membranous tube, having a cylindrical or slightly conic shape, and consisting, for the most part, of several concentric layers, united by cellular substance. The innermost coat, or that which is in contact with the contained fluid, is of a definite tissue, proper to each system of vessels, and expressly adapted for placing it in harmony with the fluid it habitually carries. Above this proper tissue, there is another membrane, in some instances, of fibrous, elastic matter, in others approaching nearer to the nature of muscle, by which the mechanical movements produced in the particular system, are wholly or partially effected. Over the whole there is, almost universally, a strong condensed layer of cellular substance, to which a great part of the strength of the vessel must be attributed.

Whenever a vessel terminates by a bifurcation, the two branches which arise exceed in the sum of their diameters the diameter of the parent tube. The vascular systems of animals, in which this form predominates, have been consequently compared to a cone, whose apex is placed in the heart, and whose base is at the circumference of the body. If the fluids, according to the common notion, passed through these tubes, as a river flows through its bed, they should, according to the laws of hydrostatics, decrease in rapidity, in proportion as they are removed from the centre of the system; but the beats of the pulse, being isochronous in all parts of the body, demonstrate that the rapidity of the circulation is universally equal. To explain this fact, it is sufficient to observe that the elasticity of the vessels preserves them constantly full, and the resistance being equal in all parts of the system, the propulsion must every where be proportionate.

The several systems of vessels, the arteries, veins, and absorbents, are intermixed with the closest intricacy in the substance of the solids, dividing and subdividing in a series almost interminable. So elaborate is this structure in the animal solids, that if any one order of vessels be injected with a coloured fluid, the whole mass will assume that colour, with such uniformity, as to appear exclusively constituted of those vessels. If the arteries be injected, the organ will seem a congeries of arteries; if the veins be distended, they will equally appear to occupy the whole substance.

This intermixture of vessels, cellular substance, and (in the animal organs) of nerves, forms the ground-work of the organic structure; they are the instruments for forming, nourishing, and animating the organ; but are not the organ itself. *This* must be considered, as consisting exclusively of the substance, which makes up its proper tissue, that essentially performs its functions, and which confers upon it its idiosyncrasy and individual character.

The proper substance of the tissue varies in every organ, and is closely adapted to the functions it has to perform. The connection between the physical properties of each tissue, and its mechanical functions, is abundantly evident. The fibres of tendons and ligaments are tough, inelastic, yet flexible. Without these properties in a tendon, much of the contractile force of the muscles would be lost; and if they were wanting in the ligaments, the bones would be subject to dislocation. The middle coats of arteries, on the contrary, are eminently elastic, by which they co-operate in regulating the circulation of the blood. Bones are hard, inelastic, unyielding, and inflexible; to accommodate them to their office of levers, for moving the body. These properties in a muscle would, on the contrary, counteract its movements; as they are obviously incompatible with contractility.

The relations of the physical properties of tissues, with their vital functions, are wholly unknown; because the intimate nature of function being itself removed from observation, its *modus operandi* cannot be understood; but that they are closely connected, cannot admit of doubt; since a change in the visible structure of organs is followed by a proportionate alteration of their functions. The induration of the liver produces a change in the secretion of the bile; the softening of the bones annihilates their function altogether.

In form, the proper tissue of nerves is pulpy; in muscles it is fibrous; in glands it is, for the most part, granular. In substance also, this tissue varies in the different organs. The proper tissue of muscles consists almost wholly of a peculiar matter termed *fibrine* or *gluten.* In bones it is an earthy salt called *phosphate of lime.* In the white parts of animals it is *gelatine ;* the basis of the woody fibre is *carbon*, and that of the softer vegetable parts is *mucilage.* From these facts it may be concluded that each individual tissue is possessed of chemical characters, which, if accurately assignable, would distinguish them no less than the differences of vital properties, which they severally exhibit.

The tissues do not combine together in the same number in every organ. The nutritive and absorbent tissues and the cellular substance may be presumed to exist in all organized compounds ; since their functions are essential to the idea of life—next to these in frequency are the arteries and veins, and last of all the nerves ; which appear to be excluded from the white fibrous tissues that conspire to produce the mechanical functions of the body ; and perhaps also in some other organs.

These parts, from their more or less general occurrence in all organized compounds, are termed *common tissues*, to distinguish them from those which occur only in one order of structures ; such as the muscular, fibrous, and osseous tissues, &c.

In the explanation of the organic constitution, which has here been attempted, the facts have been principally selected from animal anatomy; as being more manifest in their own nature, and as having hitherto been most successfully investigated. The doctrines, however, apply generally to all organized species. The cellular tissue of vegetables very closely resembles in function and in structure that of animals. Absorption is performed both by their roots and leaves, and their sap vessels are analogous to the arteries and veins of animals. The theory of nutrition, and consequently of that intimate structure, is strictly identical both in kingdoms. The oily, emulsive, resinous products of vegetables are glandular secretions, implying the presence of corresponding tissues. The woody, carbonaceous fibres are analogous to the osseous skeleton of animals. Many vegetables likewise exhibit spontaneous motion, which, though not performed in obedience to volition, implies the existence of a tissue, in many respects analogous to that muscular tissue of animals; although these organs have never been distinguished in the vegetable anatomy.

From this general similarity in the mechanism of organs, and from the identity of their functions, it is impossible to doubt that the intimate nature of organization is in all species alike, and that one force animates, one law regulates the whole. Where there is a similarity of end, there also must be inferred a sameness of means. For it is the characteristic of nature to elicit many effects from a few causes; not to adopt a variety of means for producing the same result.

The fluids, which form parts of organized structures, may be arranged under two divisions; those which are accumulated as materials for living action, and those which have undergone the process of secretion. The former consists of a very few peculiar substances, (called by the chemists proximate principles) held suspended in watery solution, and mixed with a small portion of saline matter. These proximate principles, which very closely resemble each other, exist also, with some slight modifications, as constituents of the solids. Hence the act of nutrition may perhaps be regarded as consisting in little more than their precipitation from the solvent fluid; and, on this account, the blood has, with some propriety, been called "*chair coulante.*"

The secreted fluids are of a more various and remote character, undergoing changes, during the process of secretion, which, in a greater or less degree, destroy their analogy and harmony with the living system; they are consequently removed, in most cases, from the system, as soon as they have performed the office for which they are produced.

All substances, destined to form part of the fluids of organized beings, are modified, *in limine*, by the action of the solids; water alone appearing to enter unchanged into the system, in order to act as a general menstruum. The sap of vegetables, which is strictly analogous in function to the blood of animals, though to appearance it resembles mere water, is still susceptible of fermentation, when collected in vessels. It has therefore already acquired mucilage and sugar, by the operation of the living agency. The sap of the maple yields about one twentieth of the latter substance.

The blood of animals is a fluid of a much more exalted character; the process of digestion having assimilated the food more closely to the character of the individual. While the blood circulates in the living body, it maintains its fluid form and homogeneous appearance: but, on being removed from the system, and allowed to remain at rest, it undergoes a spontaneous change; separating itself into a red solid substance, the *crassamentum;* and a thin, transparent, yellowish fluid, called the *serum:* while an odorous and pungent principle, generally overlooked, exhales and escapes.

The cause of this *coagulation* of the blood is not known; it neither depends exclusively on rest, change of temperature, nor exposure to the atmosphere. The opinion of John Hunter, who attributed this phenomenon to vital action, affords the most satisfactory explanation. The vigour of the process is proportionate to that of the living energy of the subject, from which the blood has been taken: while the coagulation is totally prevented, when the animal has been destroyed by lightning, or by any other means, which at once exhaust the whole irritability of the body.

By chemical operations, there are distinguishable in the blood, certain animalized compounds, termed *fibrine*, *albumen*, and (according to some authors) *gelatine;* which are all combinations of oxygen, hydrogen, carbon, and nitrogen; and differ from each other chiefly in the proportions of the latter element; the azote abounding in each of these substances in the order in which they stand.

These principles are chiefly distinguishable amongst each other by their affections with water. Fibrine is insoluble, even at the boiling temperature; but when heated above that point, in the machine called a digester, it yields to the solvent power of the menstruum; possibly on account of some change in its chemical constitution. It is the most highly animalized of all organic compounds, and seems especially formed for the support of muscular structures; of which it constitutes by far the largest portion.

Albumen exists nearly pure in the white of eggs, and from this fact, has obtained its appellation; it is soluble in water, from which it is again separated by heat, by the mineral acids, and by distilled spirits; in this process, it is so far changed, as no longer to be soluble, without a long continued boiling. Besides the usual elements of animal matter, albumen contains sulphur; which is familiarly testified by the discoloration of silver spoons, which takes place when they are used in eating eggs. Albumen predominates in the structure of white parts, in hair, in horn, and in cartilages; and it is a constituent of muscles, nerves, &c. &c.

Gelatine, according to some authors, is a product of nutrition, and does not formally exist in the blood. It is this principle which forms the basis of jelly, size, and glue. It is miscible with water in all proportions, and does not coagulate with heat. One part of this substance, dissolved in one hundred and fifty parts of water, assumes, when cold, the solid and tremulous form peculiar to jelly.

The saline part of the blood consists chiefly of soda, and of the muriate and phosphate of that alcali.

The red colour of the blood is derived from a peculiar substance, whose constitution is not well understood. Microscopic observation exhibits it under the form of globular, or rather of discoid bodies, having a diameter, according to Haller, equal to one five-thousandth part of an inch.*

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* Halleri Elementa, *t.* iii. *p.* 56. Desaguliers makes the diameter of the red globules $\frac{1}{79400}$ of an inch. Lieuwenhoeck estimates them at $\frac{1}{2500}$. All this however is very vague, unsatisfactory, and (fortunately very) useless.

These bodies, though soluble in water, separate from it again by deposition. When collected and burnt, their ashes contain much iron. Concerning their chemical history there subsists great difference of opinion. Fourcroy maintained that the iron exists in combination with phosphoric acid, and is suspended in the fluid by means of soda; but if this were the case, the iron should be cognizable by chemical tests; an inference contradicted by the fact. No other more satisfactory explanation has been given, to supply the place of Fourcroy's theory, by those authors, who have denied its applicability. There exists in the red globules, besides iron, a small portion of albumen.

The red globules seem to exert a marked attraction for the fibrine: they unite with it during the spontaneous coagulation of the blood, and adhere very closely to it in the muscles of red-blooded animals; still however they may be separated from each other by simple ablution.

The functions of these bodies, like their constitution, are obscure; the iron has been considered as a medium of attraction for producing that chemical change which is effected in the blood, during respiration: but as all animals respire, and the blood of a few families only contains red globules, the supposition must be abandoned, as unfounded.—In some manner, they are connected with an high developement of vital power; since they abound in the warm-blooded animals exclusively; have a more circumscribed existence in the reptiles and fish; and do not exist, except in a very few instances, in the fluids of the invertebrated classes.*

A question of some curiosity arises out of these facts, respecting the constitution of the blood, during its circulation in the body; whether, namely, it be an homogeneous fluid, of one uniform constitution; or a mixture of the proximate principles, discovered on coagulation: or in other words, whether coagulation consists in a *formation* of fibrine, albumen, &c. or merely in a *separation* of them from each other.

The insolubility of fibrine, unfavourable to its formal existence in the fluid blood, affords a strong argument in favour of the former hypothesis. If this view of the subject be correct, the azote, so unequally distributed among the proximate principles of coagulated blood, is equally diffused through the whole mass of the circulating fluid, and coagulation will then consist in a new arrangement of the chemical constituents. The constitution of the blood seems the same in all red-blooded animals; nor does it greatly differ in the same individual at the different epochs of its existence; unless when influenced by disease. Its purity, notwithstanding, is assailed both through the channels of absorption and of assimilation; but the balance of the organic functions, for the most part, preserves the constitution of the fluid unchanged. The several morbid poisons, which find their way into the circulation by absorption from the external and internal surfaces of the body, exist in the blood in too small quantities to be cognizable by experiment. The blood of a person labouring under small pox, does not sensibly differ from that drawn during any other inflammatory complaint.

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* When inflammation takes place in the white tissues of the warm-blooded animals, their minute vessels become so changed in their vital power, as to admit the entire red blood; the presence of the red globules therefore seems essential to the process.

Certain articles of diet, it is true, materially change the constitution of the blood. The sea scurvy is thus produced by the exclusive use of salted provisions. But this result seems to proceed from their action on the living solids, and not primarily by any mixture or contamination of the fluids themselves; since there is no evidence that the serum or watery part of the blood, contains a larger quantity than usual of saline matter. There is, therefore, little or no foundation, for the vulgar prejudices entertained respecting the purity or acrimony of the blood, and the existence of various humours in the circulation, tending towards disease. In corroboration of this opinion, it may be remarked that the whole tribe of '*sweetners*,' which the old ladies, both professional and empyrical, administer so liberally, are wholly inert; being more marked by their beneficial effects upon the apothecary, who prepares, than on the patient who swallows them.

The loss which the blood sustains, in supporting function, is supplied from two sources; from the chyle, or product of digestion, and from the results of absorption, both from the substance and surfaces of the whole body. Of these sources, the former alone can be considered as administering to the positive increase of the body. For though much water may be absorbed during a moist state of the atmosphere, from the lungs and skin, it seems very improbable that nutritious matter is ever obtained from these surfaces. Milk and broth baths have been constantly employed as means of supporting life, in cases of obstruction in the œsophagus, where food could not be passed into the stomach; but emaciation and death have succeeded as rapidly, as if no such remedies had been employed.

The chyle, whatever may have been the nature of the food from which it is obtained, appears nearly the same.* It is a milky fluid, which, when abstracted from the absorbents, and exposed to the air, coagulates, and acquires a slight tinge of red. This last circumstance has led to the conjecture, that chyle is converted into blood, during the process of respiration.

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* Mr. Astley Cooper asserts, that the chyle of vegetable food partakes of the nature of its origin, and putrefies less readily than that obtained from animal nutriment. This, however, is contradicted by other physiologists.

The chyle appears to contain all the proximate principles of the blood, though in a state of somewhat greater dilution. Its milky appearance depends upon the presence of white globules, seemingly identical with those, which, when acted upon by the air, become the source of the red colour of the blood.

The lymph, or common product of absorption, resembles the serous portion of the blood in its constitution. It is a watery, transparent fluid, which coagulates, on being removed from the body ; and is merely a mixture of the proximate principles obtained from the decomposition of the various tissues.

The theory of the formation of these several fluids is extremely imperfect. The organization of the chemical elements is a slow and protracted process. For though vegetables are capable of being nourished by water and carbonic acid, they do not very rapidly thrive and multiply, without the admission of matter obtained from bodies already organized. Still, however, the vegetable economy is incessantly employed in forming, from the decomposition of water and carbonic acid, those triple compounds of hydrogen, oxygen, and carbon, which constitute their appropriate proximate principles.

The food of all animals, either immediately or remotely, is found in these triple compounds; and their digestion consists in the conversion of them into quadruple combinations by the addition of nitrogen. The source from which this last element is derived, is totally unknown. Besides nitrogen, other principles, also, are found in animal compounds, such as phosphorus, lime, and iron, which do not exist in vegetable matter, in quantities proportionate to the demands of the animal organization.

With respect to the nitrogen, this element exists abundantly in the atmosphere; but it has been decidedly proved, that it does not gain admission to the blood, during respiration; and, in confirmation, it must be remarked, that the chyle of the herbivorous animals already contains nitrogen, before that fluid can be brought into contact with the atmosphere.

It has been imagined, that the predominance of nitrogen in animal compounds is derived from the very minute quantities of it, which some vegetables contain, by the elimination of the other three principles, during the various animal processes: but if this were the fact, the fluids of carnivorous animals should contain more nitrogen than those of the herbivorous tribes—a proposition positively contradicted by observation. The late Sir B. Harwood was in the habit of exhibiting the transfusion of blood, by emptying the veins of a dog, and refilling them with those of a sheep. The dog, though a carnivorous animal, enjoyed perfect health while circulating the blood of one which is herbivorous; and was not otherwise annoyed by the experiment, than from the incident fatigue and the soreness of the wound.

From these considerations it may be concluded, that nitrogen either exists as an ingredient in hydrogen or carbon (a proposition very improbable), or that it is itself a compound of some of the elements of vegetable combinations. One or the other of these hypotheses must be admitted, to explain the phenomena of animalization, since no other conceivable source exists for the fourth principle, which enters into chyle during the digestion of vegetable substances.

The same observations apply to the sulphur, phosphorus, and other constituents of organized bodies, which have hitherto eluded chemical decomposition.* Sulphur is evolved in a variety of processes, instituted both on vegetable and on animal matter; and both this substance and phosphorus exist too abundantly in the frame, to be introduced into the economy without observation. Not only the whole boney skeleton is nourished and supported through life, whose basis is a triple compound of phosphorus, oxygen and lime, but phosphorus may also be obtained from almost all the solids, and large quantities of phosphoric acid pass off daily in the urine.*

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* Un assez grand nombre d'observations me font présumer que la quantité de phosphore, qui se développe après la mort, est proportionnelle à l'activité du système nerveux pendant la vie.

Cabanis.

A great increase of probability has been given to this view of the subject, by the recent decomposition of the earths and alcalis. The monocotyledonous plants secrete large quantities of siliceous earth, which enters into the composition of their epidermis; and the entire egg-shell, which contains a very large quantity of lime, is formed by the parent bird during a few hours.† Neither of these facts can be satisfactorily explained but by the direct formation of lime and silex by the animal chemistry.

As animal matter is formed from vegetable substances, so it may be reduced to a state analogous to them by chemical operations. If a piece of muscle be exposed to the action of nitric acid, nitrogen escapes, and the mass is converted into an inflammable substance, resembling in constitution the vegetable oils. A similar result follows its exposure, for some length of time, to a stream of running water, when a peculiar matter is obtained closely resembling spermaceti, which has obtained the name of *adipocire.*

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* See Davy's Elements of Chemical Philosophy, p. 480.

† Vauquelin likewise discovered twice as much *phosphate of lime* in the excretions of birds as exists in the grain from which they are fed. The formation of lime by the animal powers seems general law. Of this fact coral and chalk rocks afford decisive evidence.

With respect to the saline ingredients of the blood, culinary salt and some earthy sulphates may be taken in with the food, and pass undecomposed into the circulation. Soda, phosphoric acid, lime, and perhaps iron, are more probably derived from absorption; the phosphate of lime being formed by the nutrient vessels of the bones; and the soda during the secretion of bile by the liver.

To the animal fluids produced by secretion, few general observations can be applied. Each particular product having a specific office to fill, it has properties peculiarly adapted to that end. They all differ more or less widely from the blood, the common material from which they are produced, but all exhibit some traces of their origin, by the presence of albumen or fibrine in their composition. They generally also contain the same proportion of saline matter as is found in the serum of the blood.* The bile and urine, however, which differ the most widely from the circulating fluid, contain peculiar salts evolved during the process of their secretion.

Burzelius has asserted that the secretions destined for elimination are acid, while those which return to the circulation are of an alcaline constitution. This remark, though perhaps not entirely just, is so far founded, that animalization in its progress tends towards the production of oxides and acids, with double and triple bases. Hyper-animalized matter may in general therefore be presumed to contain a predominance of acid in its combinations.

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* Young's Medical Literature.

CHAPTER III.

OF THE COMBINATION

OF

ORGANS AND FUNCTIONS.

THE number and combinations of organs regulated by a strict necessity—Uniformity of Organization—Assimilating Organs follow two types, animal and vegetable—Various Organs of Mastication and Prehension—Teeth of herbivorous and of carnivorous Animals—Brief statement of the facts connected with Digestion—Structure of the Alimentary Tube—Interior Mucous Coat—Gastric Juice—Muscular Coat—Peritoneal ditto—Two leading forms of the Intestinal Canal, carnivorous and herbivorous—Other Varieties—Liver connected with digestion, and with sanguification—Bile, its Functions—Reasons for supposing the liver a decarbonizing organ—-Pancreatic Secretion—Spleen—-Circulating System—Animal and Vegetable Types—General Views—Propulsion of blood through the Capillaries—Varieties in these structures dependent on the respiring organs—Agency of Organized Beings on air—Relation of Respiration to Muscular Motion—Respiratory Organs of Birds, Mammalia, Reptiles, Fish—Of the inferior animals—Varieties of Mechanism in the Organs of Respiration—History and Theories of Respiration—Hippocrates, Boyle, Willis, Meade, the Pneumatic Chymists—Phenomena of Pulmonary Function—Phenomena and Theory of Animal Heat.

OF THE SECRETIONS—General Remarks—Exhalation, follicular and glandular secretions, an unfounded distinction—Secretions the result of Vitality—Glands, secreting and lymphatic—Of the secreting glands, those which are subservient to nutritive life are the most constant—Mucous Membranes, serous Membranes—Urinary Organs—Urine of carnivorous and herbivorous Animals—Uric Acid—Skin considered as an organ of secretion in various animals—Relation of the perspired fluids to the urinary and intestinal secretions—Causes of variety in the glands connected with relative existence.—NERVOUS APPARATUS—Difficulties—Deductions from comparative anatomy—Nervous Functions of all animals the same—Subordinate functions of the different nervous organs—Cerebral and sympathetic systems—Brain not the specific organ of perception—Adaptation of nervous apparatus to external nature.—BONES—Three Types of animal structure—Structure of Bone—Boney Earth—Primordial Cartilage—Ossification—Mollities Ossium—Mechanical Remarks.——MUSCLES, Modifications, mechanical facts, Tendons, Aponeurosis—Combined Action of Muscles—Antagonist Muscles—Relation of Nerves and Muscles—OF THE GENERATIVE SYSTEM—Ignorance on this subject—Influence of the generative system on the general organization—Limitation of Species—Monsters—Mutual Influence of Species—Plurality of Worlds.

CHAPTER III.

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ORGANS AND FUNCTIONS.

> *'Ουδὲν γὰρ πώποτε ζωον γεγένηται τοιοῦτον, ὅ, τὸ μὲν ἔιδος ἐσχεν ἑτέρου ζώου, τὴν δὲ διανόιαν ἄλλου· ἀλλ᾽ ἀέι τοῦ αὐτοῦ, τὸ τε σῶμα καὶ τὴν ψυχὴν, ὥστε ἀναγκᾶιον ἕπεσθαι τῷ τοιῷδε σώματι, τοίανδε διάθεσιν.*
>
> ARISTOTELIS OP.

AS the character of the different tissues and fluids of organized beings is a result of the chemical properties of their constituent elements, so also the forms and combinations of their organs are calculated upon similar necessities; being neither arbitrarily instituted, nor susceptible of indefinite variety. The organs of nutritive function (more especially) are fixed, both in number and in structure, by laws which admit only of slight deviations; and if the organs of relation allow of a greater seeming latitude this circumstance arises solely in the more extensive range of phenomena, with which their existence is destined to harmonize.

To this necessary connection may be traced that uniformity which pervades the whole organized world, and by which nature in her wildest ranges, seems confined to the observance of one architypal model. To this cause must be assigned the universal vascularity of organized structures, the general presence of the same elements in all vegetable substances, and the like identity of composition in animal species. The regular distribution of vegetables into root, stem, and branches, and that of animals into head, trunk, and extremities, in like manner imply the pressure of some common necessity; and in those species in which an occasional departure from this model is exhibited, the causes of such deviation must be sought in some local or intrinsic circumstances peculiar to the individual.

The assimilating organs, though common to all living beings, exist under various degrees of complexity. Latitude and force of function being dependent upon a recondite chemical constitution of the solids, and being accompanied by a corresponding consumption of the fluids, the nutritive processes increase in energy and in complication in proportion to the general powers of the rest of the machine. The assimilating apparatus is, however, reducible to two general types; that of the vegetable and that of the animal organization. The roots of vegetables, in absorbing the nutritive substances, by which they are surrounded, convert them at the same time into that mucilaginous and saccharine substance, which constitutes their circulating fluid, without the intervention of a specific and local organ of digestion; but it is evident that animals, compelled to take their food at intervals, not so much suited to their wants, as to their means of obtaining it, require an internal arrangement, which shall provide a reservoir, to contain the materials of their nourishment; and enable the individual to provide for other necessities, pending the conversion of the aliment into chyle. Such a storehouse is the stomach, the most universal of the animal organs.

Digestion, the function of the stomach and intestines, is a process so constantly connected with animal existence, that the presence of its organs has been adopted by naturalists as the best criterion for distinguishing between vegetable and animal forms. As the several articles of nourishment very closely agree in their elementary constituents, and as, on the other hand, the proximate principles of the animal fluids have a general resemblance, the necessities of all animals with respect to the digestive processes are nearly alike; and their assimilating organs, consisting of the same tissues, differ from each other chiefly in those arrangements which are connected with the physical properties, and external circumstances of their articles of habitual diet.

There is no part of the animal structure more varied than the organs by which prehension and mastication, the first of the assimilating processes, are performed; and so rigidly are they modelled according to the properties of the food upon which each animal subsists, that they afford the most constant characters by which the genera of the higher and more noble animals may be determined.

The substances employed as food are of every possible consistence, hard, soft, solid, fluid. They are placed on the surface of the earth, under the water, or in the air; the food likewise may be dead and passive, or alive and capable of making resistance or escape. To all these varying circumstances the mouth and teeth of each animated species are adapted, by corresponding peculiarities in their mechanism and organization. The grinders of herbivorous animals, for example, are smooth, and constructed for triturating vegetable substances; while, in carnivorous animals, they are uneven and indented, so as to be calculated for tearing and dividing the animal fibre. The front teeth of such animals as crop or bite their food, are sharp and flat, and are so placed, as to imitate, in their mutual action, the play of a pair of scissars. The canine teeth on each side of the jaw of the predacious animals are extended to a disproportionate length, and are thus converted into weapons of attack. In the elephant the same arrangement exists, to provide an instrument for ripping the trunks of young succulent trees, upon which that animal delights to browse.

The predacious fish, which swallow their prey entire, and do not masticate their food, have teeth adapted exclusively to seizing and retaining their victim. For this purpose they are arranged in rows over the tongue, palate, and throat, and are curved back towards the stomach, to prevent the regress of what has once entered the jaws.

The bills of birds are not less accurately adapted to the nature of their food. Strong and hooked in the carnivorous and predacious tribes, they are fitted for war and conquest. In the smaller families, which feed on worms and insects, they are soft and almost flexible; while in such genera as subsist upon seeds, and require to detach their hard husks, they are sharp pointed, and of a horny consistence. The breadth of this organ in the duck tribe, enabling the animal to seek its food on the surface of shallow waters, and its length in the woodcock, an animal that draws its prey from soft, marshy ground, requires no comment.*

Mastication is not necessary, when the food exists naturally in a pultaceous or fluid form. Its operation, also, is, in very many instances, supplied by the energy of the solvent juices of the stomach; and in the gallinaceous birds the functions of the teeth are performed by a peculiarly muscular stomach, or *gizzard*, which exerts an enormous pressure on the food, and prepares it for solution. To form some notion of the comminuting force of this organ, it may be stated, that Spallanzani inserted the points of lancets in leaden bullets, and thrust them into the gizzards of turkies; when, though the organ was uninjured by the experiment, the lancets were destroyed by the action of the gizzard.

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* Cuttle fish, which prey upon the small crustaceous animals, have a horny beak like that of the predacious birds.

The necessity for mastication, in whatever animal it prevails, implies the existence of muscular lips, a flexible tongue, and a gland, or system of glands, to secrete the *saliva*, by which, during the mastication, the food is moistened: and it is in such animals alone that these organs are perfectly developed.

The phenomena of digestion have occupied, for a long series of years, the attention of physiologists; but have hitherto, in a great measure, eluded their inquiries and comprehension. It would be neither useful nor interesting to detail the various theories of maceration, trituration, fermentation, &c., which, founded upon partial and inadequate views, have long been disproved.* Thus much is only experimentally known: that the food, after deglutition, is received into the stomach, where it is retained for a considerable time, and exposed to the action of the natural secretions of that organ, by which it is slowly dissolved, and reduced to a greyish, uniform, pultaceous mass, called *chyle.* As soon as this change has taken place, the inferior orifice of the pylorus, which had previously remained closed, is opened by the relaxation of its sphincter muscle,* and the chyme passes into the superior portion of the intestine, called the duodenum. In the duodenum, the chyme is exposed to a copious secretion of bile and pancreatic juice, whose agency is wholly unknown. The effect, however, is a precipitation of the nutritious portion of the food, or chyle, from the fæculent residue. The chyle does not mix with the rest of the mass, but adheres to the coat of the intestine, and is seen entering the absorbent vessels under the appearance of a milky fluid. In the inferior portion of the alimentary tube, which, from its larger diameter, is called the great intestine, a third change takes place in the residue of the alimentary mass (now totally deprived of its chyle);

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* Voltaire, though no physiologist, saw through the absurdities of these speculations of cotemporary physicians, who explained physiological facts successively by mathematical and chemical principles, as those branches of science were fashionably prevalent. "Je laisse," he observes, "Borelli attribuer au cœur une force de quatre vingt mille livres, que Kiel réduit à cinque onces. Je laisse Hecquet faire de l'estomac un moulin et Van Helmont un laboratiore de chimie."—*Dialogues.*

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* Sphincter muscles are those which close orifices. They are formed by circular arrangements of muscular fibres, so placed about the orifice upon which they operate, as, by their contraction, to obliterate its cavity. The natural condition of a true sphincter, contrary to that of other muscles, is that of contraction. The term is derived from the Greek σφιγγω, to constrict.

in consequence of which it assumes its fæcal appearance and qualities. Upon this function of the intestines experiment has thrown no light. Physiologists are also in equal ignorance of the course which is pursued by the merely diluent fluids. The rapidity with which certain substances find their way into the excretories leads to a conviction, that the watery fluids pass at once into the circulation ; but the route by which they are so conveyed has hitherto been hidden from investigation.

Upon the scanty basis of these few facts it is vain to theorize. There are persons disposed to consider the phenomena of digestion as electric ; Dr. Wilson Philip has succeeded in continuing the process, after it has been suspended by the section of the eighth pair of nerves, by passing a galvanic current through the region of the stomach. This experiment, although it affords ground of probability in favour of the identity of the nervous and galvanic agency, in strictness, proves only, that the latter is one amongst the most powerful stimulants of the living tissues. Until electricity can be so applied as to produce the same results in chemical vessels, it will still be necessary to attribute them to that unknown force, which governs all other living operations, the vital energy. But to return—

The Zoophytes which, in so many particulars, hold a middle place between the vegetables and superior animals, appear to subsist upon the assimilated juices of the species on which they prey; without operating upon them any considerable change. Their digestive organ consists in a simple stomach, or muscular bag, having but a single orifice, for the passage both of the food and of the egesta. In every other order the alimentary tube is of considerable length, having one or more dilatations or stomachs, and exhibiting certain peculiarities of structure, in different portions of its length, coordinate with corresponding differences of function. There are always two distinct orifices for the reception of the food, and for the passage of the fœcal residue.

The internal coat of the intestinal canal, like every other internal surface which is brought into contact with foreign substances, is of that order of tissues which has obtained the appellation of mucous membranes. These tissues, though exhibiting many modifications, in the different organs in which they are found, maintain a general character in all; a character affording many analogies with that of the skin. Some polypes, when turned, like the finger of a glove, inside out, continue to live, and to digest with that surface which had previously occupied the exterior of the body. The mucous membranes, which line the surface of the alimentary canal of the lungs, kidnies, nose, &c., appear to possess properties which vary in consequence of their different degrees of vitality, but which still have a certain degree of resemblance from the identity of their structure ; and in this respect they do not more differ from the skin than from one another. They are all capable of absorbing from their surface, though with different degrees of intensity ; they all likewise appear to vitiate the atmosphere, when in contact with it, by converting its oxygen into carbonic acid ; and they all secrete a fluid, which exerts a solvent power upon the several alimentary substances. But though these properties are in some degree common to all the mucous tissues, yet in the higher classes of animals the mucous membrane of the lungs is alone capable of supporting life by respiration, and that of the stomach exclusively possesses solvent powers sufficient for the nourishment of the body.

Mucous membranes are parts of great vital energy and vascularity. They abound in absorbent and exhalent vessels, and are largely supplied with nerves. They are likewise beset with numerous small glandular bodies, termed *follicles*, which secrete the peculiar fluid from which the tissue derives its name. The mucous secretion has, in general, a certain degree of tenacity, subservient to the defence of the membrane from too rough and violent an impetus of the substances which come in contact with it. It varies, however, in the different organs, to accommodate itself to their several functions. The mucous secretion of the stomach is viscid, and unmarked by any peculiar appearance which should indicate the activity of its solvent energies. These energies, though intense in all animals, are most remarkably so in the carnivorous species; since in them it is capable of dissolving even the osseous tissue. In that remarkable case, which occurred in St. Thomas's Hospital, of a man, who had swallowed several clasped knives, the horn handles were found, after death, all more or less perfectly corroded.

The gastric fluids have likewise the singular power of coagulating albumen. It is on this account that the stomachs of calves, impregnated with their own juices, are salted and preserved for the use of the dairy, to turn the milk in the manufacture of cheese. By macerating this substance in warm water, enough rennet may be obtained from it to coagulate six or seven thousand times its weight of milk.* The albuminous fluids, when taken into the stomach are first coagulated, and afterwards dissolved by the gastric juices.

Such are the general circumstances attending the mucous membrane of the stomach. In the rest of the intestinal canal the secretion does not exert the intense solvent and coagulating power, exhibited by the gastric juices. The vitality, also, of the intestines appears to be less developed than that of the stomach, and their functions much more circumscribed; being, perhaps, confined to the absorption of the chyle; and contributing little to the concoction of the aliment.

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* Bell's Anatomy.

The passage of the food through this complicated tube is regulated by a coat of muscular fibres, which adheres externally to the mucous membrane, and differs in its various portions according to the necessities of the part. The muscles which operate upon the commencement of the tube are under the dominion of the will, deglutition being performed at the pleasure of the animal; but when the food has entered into the alimentary canal, its further progress is regulated by the stimulating properties it acquires, in its several successive changes. The muscular fibres of this coat are so placed, that by their contraction they diminish the cavity of the canal. They do not all act simultaneously, but different portions in succession, so as to confer upon the bowel a movement, which resembles the creeping of a worm. In the stomach, besides this *peristaltic* movement, as it is termed, the muscular fibres exert a constant and graduated contraction, which causes that organ to close on its contents, whatever may be their bulk, and to preserve it in all its conditions, without any vacuity or unoccupied cavity. To counteract this force, and to retain the food in the stomach until it shall have undergone the full action of the solvent juices, the distant orifice of the stomach, or pylorus, is closed by a sphincter muscle; an arrangement which denies a passage to the contents of the organ, except when that muscle is in a state of relaxation.

Throughout all that portion of the intestinal canal which lies within the abdominal cavity, it is lined exteriorly to its muscular coat by a serous membrane, termed the *peritonæum*, whose functions are, however, not immediately connected with the digesting process.

The alimentary canal then consists essentially in all animals of a mucous membrane, possessing living powers of action, and secreting juices adapted to the solution and assimilation of the food; and of a muscular coat, superimposed on the mucous membrane, calculated by its structure to regulate the passage of the nourishment, in the several stages of its descent.

This general arrangement admits of but two leading modifications, arising out of the nature of the substances upon which the organs are calculated to act. In those animals which feed upon vegetable matter, whatever rank they may otherwise hold in the scale of beings, the digestive organs are complicated and voluminous; while they are shorter and more simple in every carnivorous species.

In carnivorous animals all the arrangements are calculated for affording the food a ready and short passage: the two orifices of the stomach are placed opposite to each other, and nearly in the axis of the alimentary canal: while in the herbivorous species these parts are situated nearer to each other, so as to render the stomach almost a *cul de sac.* In carnivorous animals, the length of the intestines seldom exceeds five times that of the individual. In herbivorous animals it is much more considerable. In the ram, for instance, it is nearly twenty-seven times the length of the animal. Besides this vast longitudinal increase, the alimentary canal of different herbivorous tribes is enlarged in lateral dimensions by several peculiar arrangements. The ruminating families have three very ample sacks, or supernumerary stomachs, besides that in which true digestion is performed. In some other families, the increase of surface is effected by a dilatation of the large intestines. The intestinal canal of those animals which subsist indifferently upon the products of both kingdoms, holds a middle place between that of the carnivorous and herbivorous tribes. In the human subject the intestines are about six or seven times the length of the body.

The relation thus established between the organization of the alimentary canal and the food upon which it is destined to act, is sufficiently evident. The sum total of changes which require to be effected in converting animal matter into chyle is necessarily smaller than that by which the animalization of vegetable food is produced; at the same time that the hard and unyielding fibres of a plant afford much more resistance to the living action of the stomach. The proportion of chyle also, which a given quantity of vegetable food can produce, is smaller than that obtainable from a like portion of animal matter. On these several accounts it becomes necessary that vegetable food should remain longer in the intestines; and also that there should exist a reservoir capable of containing larger portions of aliment at the same time.

The necessity for these different arrangements influences considerably the outline of the various animals of the class Mammalia. The carnivorous animals having but little intestine, are small in the loins, and exhibit less protuberance of the abdomen, while the swiftness and strength, requisite for the capture of prey, are marked by a comparatively broad and deep chest. Herbivorous animals are characterised by large bodies, and, with a few exceptions, by a smaller developement of chest.

The observations here detailed on the structure of the intestines, are applicable alike to all orders of animals,* so that the habits of an unknown species may be ascertained by dissection, or the anatomy may be presumed from an acquaintance with its manners. Even those insects, which in a caterpillar state feed on the leaves of plants, but which, when perfect, suck the honey of flowers, undergo, during their metamorphosis,* a corresponding change in the organization of their intestinal canal. They thus afford a beautiful illustration of the position that the phenomena of life are deductions from the physical laws of matter; and that the varieties of structure in the several organs are consequences of the properties of those bodies, with which they stand in immediate connection.

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* The length of the intestinal canal is proportionably greater in the mammalia than in the other classes, and diminishes successively in birds, reptiles, and fishes. In some of the rapacious fish, it is even shorter than the body.

In attempting to ascertain the various circumstances which determine the existence and developement of the several organs, the enquiries of the physiologist are necessarily limited to those parts whose functions and utility are clearly appreciated. Wherever the purposes which a part fulfils in the economy are imperfectly understood, its connections with external nature are no less obscure, than those which it maintains with the rest of the machine.

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* The metamorphosis of insects is a very curious fact, though now familiarly known to most readers. In the first condition of the animal's existence, which is termed the larva, or caterpillar state, insects are extremely voracious; their increase in size is rapid, and their alimentary organs greatly predominate in the system. "Tout est estomac (says de Tigny) dans une larve, depuis l'esophage, jusqu'à l'anus." In the last or perfect state, they take little or no sustenance: the intestinal canal dwindles and gives place to the generative organs, which now assume the mastery, and influence almost exclusively the morals of the animal. In the most noble animals there takes place a change in the functional force of organs, and a revolution of instincts and habits, at the epoch of puberty, which bears some faint analogy to the metamorphosis of insects.

This observation applies with particular force to the liver, which, though an organ of great size, and predominantly influential in the constitution, performs functions whose necessities are by no means well understood. The importance of this viscus in the animal economy may be inferred from its early developement in the fœtus, and from its universal existence in every animal possessed of a heart. Even insects, though devoid of other glands, secrete from the internal surface of certain membranous bags, a yellow fluid, apparently equivalent to bile.

The chemical constitution of the bile has been diligently studied and is well understood; but the relations of its elementary constituents to its operation in precipitating the chyle are not thereby rendered more intelligible. The bile is an oily or soapy compound of a greenish yellow colour, of a viscid consistence and intensely bitter taste. The oily matter it contains approaches in its properties very nearly to the character of spermaceti; and it is held suspended in the fluid by a very large quantity of soda, and by some albuminous matter having a strong tendency to putrefaction.* In what manner this alcaline product contributes to the formation of the chyle cannot even be conjectured. Though the digestive functions are deranged by an obstruction of the gall ducts, though flatulence and dyspepsia are the usual concomitants of jaundice, yet an absolute suspension of the chylopoietic action is by no means a constant consequence of the absence of bile in the intestines. From the cathartic effects of the artificial soaps, physiologists have been inclined to consider the bile as the natural stimulus of the intestines; and there seems some reason for the supposition, since the presence of an unusual quantity of this fluid in the alimentary canal increases, in an inordinate degree, the force of the peristaltic motion. The early developement of the liver in the fœtal economy, at a time when the functions of the intestinal canal are in abeyance, and this organ, as a part of the alimentary system, is perfectly useless, has led the French physiologists to imagine that it is in some way connected with the maintenance of the peculiar healthy constitution of the blood. The great size of this organ likewise adds probability to the hypothesis, since it is much larger than would suffice for the mere formation of the bile, which in quantity is perhaps inferior to the saliva. The liver, especially that of fish, is a viscus abounding in oil; and the quantity of carbon and hydrogen which this substance, as well as the constituents of the bile, contains, seems to warrant the supposition that these elements are abstracted from the blood in that organ. It will be stated in a future page, that the abstraction of carbon from the blood is the immediate function of the lungs, and that this function is momentarily essential to life. In the fœtus the decarbonizing process has not commenced in the lungs; and it is not impossible that the large size of the fœtal liver may arise from the activity of that viscus, as vicarious to the respiratory organs. But that the liver really does operate this change upon the blood, is by no means proved. There is, however, this additional argument in favour of the supposition, that it is the only gland which receives the materials of its supply from the veinous system, whose blood is characterised by a superabundance of carbon. The Greek physicians attributed to the liver a large share in the manufacture of the blood; and its extensive influence in the constitution is certainly not compatible with its limited action, as one of the chylopoietic viscera. But before the French theory can be admitted as more than mere conjecture, there is one point essentially necessary to be proved, which is, that secretion is performed by a *selection* of the elements of the blood, and does not consist in changes effected in the *entire mass* of fluids upon which the glands operate.

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* Fourcroy.

The utility of the pancreatic fluid in the business of digestion, is still less obvious than that of the bile. It is a transparent liquid very closely resembling saliva, and on this account has been most absurdly supposed a contrivance for diluting the bile. In man, and in many of the mammalia, there exists an appendage to the liver called the *gall bladder*, expressly formed to accumulate and concentrate the bile (by absorbing its watery parts) during that time when the duodenum and stomach are empty; and which pours its contents into the intestine at the period when the bowel is distended by chyme. The co-existence of an organ to concentrate and another to dilute the bile, is a manifest absurdity.

The pancreas is not a gland of very general occurrence in animal systems; it does not formally exist in any known family of fish, except the shark and the skate; in the other fish, however, there exists a complex cluster of organs called the *pyloric* cæca, that elaborate a fluid, which naturalists have deemed analogous to the pancreatic secretion.

Connected with the digestive apparatus in situation, is the spleen, an organ whose functions are wholly unknown. It exhibits no irritability, it has no excretory duct, nor has any thing satisfactory been discovered, respecting its ultimate structure. Its existence is exclusively confined to the animals of the class mammalia; and amongst these, it exhibits many varieties of size, shape, colour and situation.

As these data admit of but few legitimate conclusions, the hypotheses concerning the functions of the spleen have been proportionately numerous. For explanations of phenomena abound, in the ratio of the real obscurity of the subject to be explained, exactly as specifics are numerous when the disease is incurable. The spleen was by the ancients considered as secreting the *atra bilis*, that imaginary humour, which figured so largely in the Galenic physic; it has by the moderns been deemed a cushion for the repose of the stomach, and it has with more probability been regarded as a diverticulum for receiving, during the quiescent state of the stomach, a quantity of blood, necessary to its increased vitality, during the activity of its function: some authors have imagined the spleen to be ancilary to the hepatic, rather than the gastric circulation. Latterly experiments have been conducted with a view to prove that the spleen is the seat of that absorption by which the fluid contents of the stomach are carried into the system; but no satisfactory result has thus been obtained. The spleen has been also removed for the purpose of discovering its functions; sometimes the animal has appeared to suffer little from the injury; at other times digestion has been impaired by the operation; but no constant consequence has followed from this experiment.

Of the Circulating and Respiratory System.

The fluids of all organized beings appear to be contained in vessels; and they are with a very few exceptions, preserved in a state of more or less rapid motion. In the simpler organizations the motion is derived exclusively from the irritability of the vessels themselves. The vegetable tribes, for instance, circulate the sap on which they are nourished by this force, which is called into action by the stimulus of a warm atmosphere: the permanence of their vital constitution allowing of occasional remissions of living function, their circulation may safely be trusted to a cause thus accidental and intermitting. The sap flows during the warm days of summer, is checked during the night season, and is wholly suspended during the winter, without endangering the existence of the plant.

The animal circulation, on the contrary, requires to be continued unremittingly, from the first moments of fœtal existence until the last pulse of life; and a suspension, but for a few minutes, is in the higher families fatal to the individual.

The complicated nature of the animal organization, and the variety of position into which its parts are thrown, afford likewise powerful obstacles to the free passage of fluids through their vessels, and these two causes necessitate the existence of an heart or embolus, whose exalted energy shall give impetus to the circulation, and preserve unabated the flow of the blood to all parts of the system.

The circulating system of the higher orders of animals, in which it is most perfectly developed, consists of the arteries, veins, and lymphatics; of which the two last may be considered as forming one system, while the arteries constitute another. If, for the sake of perspicuity, each of these systems be considered as a single vessel, the circulating apparatus may be represented as a reservoir, consisting of an heart, artery and vein, joined continuously and in a circle with each other. Through this circle the blood moves in an endless succession, giving off, at every revolution, a quantity to the secreting and nutritive vessels, from the arterial side, and receiving the products of absorption and digestion on the veinous.

Between the termination of the vein and the commencement of the artery, is placed the heart. This is an hollow muscle, containing at least two chambers, termed an auricle and a ventricle; and provided with a valvular apparatus for preventing the reflux of the blood at the moment of contraction. In this arrangement, the auricle corresponds with the vein, and the ventricle with the artery. As soon as sufficient blood has flowed from the vein to distend the auricle, it contracts, and forces its contents into the ventricle, and the ventricle, in its turn distended, contracts also, and propels the blood forward into the artery; the movements of the two chambers are therefore alternate.

The impetus, which the blood receives from the contraction of the ventricle, slightly distends the arterial system, to its remotest branches: the elastic coat of these vessels yields under the pressure; but re-assumes its former diameter as soon as that pressure ceases; the existence of valves at the orifice of the aorta, or trunk of the arterial system, prevents regurgitation into the heart, and a quantity of blood is consequently expelled through the minute branches of the system, equal to that which was received from the ventricle.

The causes of propulsion, which carry the blood beyond this point of the circulation, are not accurately appreciated: it seems however probable that when that fluid arrives in the minute capillary system, it is no longer under the dominion of the heart, since the beating of a pulse is not perceptible in these organs. It appears most consonant to analogy, to attribute the ulterior progress of the blood to the living energy of the capillaries, exerted partly by a movement of their sides, approaching to the nature of muscular motion, and partly perhaps by an absorbent power in the orifices of the veins. However this may be, the larger veins are perfectly passive; the blood being propelled through them by the vis a tergo, occasioned by new quantities of fluid entering their orifices. On this account the veins are provided with valvular duplicatures of their innermost coat, wherever there is danger that by forming long columns, the weight of the fluid should impede the circulation.

Such in the most perfect abstraction is the circulating system of animals; but it admits of some curious modifications in the different classes, occasioned by the subservience of this function to that of respiration.

It is a general fact that every living being requires to be placed, directly or indirectly, in contact with atmospheric air. In the more noble animals its action is of incessant urgency, and its absence even for a few seconds, is sufficient to suspend animation. The nature of the changes effected upon living tissues by this agent, has not been fully investigated; but it should seem, as if every living solid, when brought into contact with atmospheric air, is liable, in a greater or less degree, to alter its constitution, and to be reciprocally affected itself. Many of the simplest animal species act upon the air by their whole surface, and have no organ exclusively appropriated to respiration. But vegetables in general, and all the higher orders of animals, breathe through specific organs, which, in plants, are the leaves, and in animals the lungs or gills. Many experiments have proved that the same changes which result from respiration, are produced in a lower degree by the external surfaces of the soft skinned animals; and Spallanzani found that reptiles, when deprived of their lungs, still operated a similar alteration. Hence it should seem that the existence of a local organ of respiration depends rather upon relations of quantity, than upon any thing peculiar in its function, which is necessary to existence.

The respiratory process in all organized beings, consists in an action, exerted by the air upon the circulating fluids; by which a mutual change takes place in their constitution. In the red-blooded animals, this change is evident to the senses. A very superficial observation is necessary to detect a material difference in the blood, which flows from an artery, and that which proceeds from a vein, when either of these vessels are wounded. The former, to omit other distinctions, is of a brilliant vermilion colour; while the latter has a deep purple hue, approaching to black: a closer inspection demonstrates that the changes which this difference implies, take place during the performance of functions in the minute capillary vessels, which unite the arterial and veinous systems; the purple blood becoming vermilion in the capillaries of the lungs, and regaining its darker hue in those of the rest of the system.

It is shewn by numerous facts and experiments, that the purple veinous blood, if by any means it find a passage into the arterial side of the circulation, is a deadly poison, striking with palsy every organ to which it gains admission. Accordingly anatomy demonstrates that the lungs are not nourished by the blood, which circulates through them for the purpose of respiration, but have appropriate nutritive arteries,* like other organs.

The more or less urgent necessity for this aëration of the blood, determines at once the relations of the circulating and respiratory apparatus. In all beings, endowed with a common centre of circulation, respiration is performed by a local organ, so placed, with respect to the heart, as wholly or partially to aërate the blood at each circulation; the utility of this organ depending immediately upon the possibility of bringing all the blood in succession to one central point in the circulation. Thus the leaves of vegetables, which have no centre of circulation, are attached to every gem; and insects, whose fluids may be considered as stagnant, are supplied with air vessels which permeate all parts of the body; the respiratory and circulating functions being reversed in these animals.

The degree of aëration, which the nutritive fluids of different animals require, is connected with the quantity and activity of their general functions; and more especially with that of muscular motion.†

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* The bronchial arteries.

† L'histoire des rapports qu'on observe, dans les divers animaux, entre les quantités de leur respiration, et l'énergie de leurs forces motrices, est une des plus belles démonstrations que l'anatomie comparée puisse fournir à une théorie physiologique; en même tems qu'elle est une des plus belles applications de cette anatomie comparée à l'histoire naturelle.

Cuvier Leçons, T. iv. p. 501.

The muscular and nervous tissues are, of all parts, the most abundantly supplied with blood; and in proportion as these systems are developed, the sum total of blood is increased, and the necessity for a more powerful and voluminous organ of respiration is rendered more urgent.

Of all animated creatures, birds possess the most extensive powers of loco-motion. Being heavier than the air, they cannot remain suspended in that fluid without an exertion of muscular force, that far exceeds the greatest energies of the brute creation. The respiratory organs of birds are therefore the most completely developed. In addition to their lungs, they are furnished with air cells, which occupy the great cavities of the body, and their bones instead of being filled with marrow contain air. This arrangement not only tends to lessen the specific gravity of the animals, as authors have assumed, but facilitates respiration, and prevents the necessity for too frequent inspiration during the rapidity of flight.

Next to birds, man and the viviparous quadrupeds enjoy the greatest muscular power; their organ of respiration is perfect; but they have nothing in their structure analogous to the air cells of birds.

These two classes of beings embrace all the hot-blooded animals, whose temperature is permanently above that of the medium in which they live: the perfection of their respiratory organ consists in its being so connected with the vascular system, as to receive the whole mass of blood at every circulation.

For this purpose they are provided with a double heart, and the circulation through the lungs is distinct from that through the rest of the body. There are in fact two circulations, the pulmonary and the systemic; the pulmonary circulation is placed between the termination of the systemic veins, and the commencement of the systemic arteries, and is governed by the right side of the heart. The blood is received from the systemic veins by the right auricle, and is impelled by the auricle into the right ventricle, and thence through the pulmonary artery into the lungs, where it is subjected to the influence of the air. The pulmonic veins receive the blood thus aërated, and convey it to the left auricle. The systemic system, beginning at the left auricle, is continued through the left ventricle to the systemic arteries, and thence by the veins, round again to the right side of the heart, to begin a new circuit.*

By this arrangement of the circulating and respiratory organs, not a drop of blood finds its way into the systemic arteries, without being aërated. In cases of suffocation, when the blood, in permeating the pulmonary vessels receives no influence from the air, but is returned purple to the left side of the heart, the vital functions are immediately suspended.

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* The motions of the two sides of the heart are isochronous; the auricles first contracting together, and then the ventricles.

The vitality of reptiles is not so closely dependent on the presence of air; their respiration is therefore imperfect. The heart in these animals, though differently constructed in the different families of the order, is in all so constituted as to perform the functions of a single organ. The pulmonary arteries do not form a circulation apart from that of the general system, but arise from the aorta. Instead therefore of receiving the whole blood at each circulation, the lungs act only upon a small portion; and this portion, after traversing the pulmonary tissue, is carried back by the pulmonary veins into the veinous system, where mixing with the purple stream, it confers upon the mass an imperfect degree of aëration; greater or less, according as the pulmonary artery bears a larger or smaller proportion to the aorta, from which it proceeds.

The muscular energy of these animals, like the aëration of their blood, is inferior to that of the mammalia. Even the snakes, whose motions are occasionally rapid and violent, are incapable of long continued exertion, without extreme consequent exhaustion; and on this account they make but a feeble resistance when attacked immediately after having hunted down and swallowed their prey.

In fish the heart is a single organ; but it differs from that of the reptiles in corresponding exclusively to the pulmonary system. The whole blood, which passes from the systemic veins into this organ, is propelled through the pulmonary artery into the gills; and the pulmonary veins uniting into one trunk form the aorta, through which the blood flows by the impetus it has already acquired, and without the intervention of a second or left-sided heart.

The respiratory mechanism in fish is therefore perfect, all the blood passing the gills at each circulation; but the aëration it receives in those organs is not proportionately extensive. Immersed in water, the gills are capable of exerting an action on those small portions only of air which that fluid can hold dissolved. The effect, therefore, must be much smaller than when the respiratory organ is placed in immediate relation with the atmosphere itself. On this account the function cannot be estimated as very high; and the muscular energy of the animal corresponds with this calculation. The specific gravity of fish being nearly equal to that of the fluid which they inhabit, their movements are performed with the exertion of but little force: yet the largest fish are speedily exhausted, when forced to put forth their whole strength in the attempt to escape from the angler's hook.*

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* The whale tribe, whose strength is so formidable, it must be remembered, belong to the class mammalia, and enjoy a perfect respiration.

Analogies of function are less easily traced in the lower classes of animals. The respiratory organs of the more perfect mollusca resemble those of fish: the respiration of insects must be rated very high, and commensurate with their extensive powers of motion; since the air vessels which permeate their bodies place almost every particle of their substance in contact with the atmosphere. Spallanzani affirms that caterpillars consume as much air, in a given time, as frogs; and butterflies much more than either.*

The relation between respiration and muscular motion is observable even amongst individuals of the same species: the strongest animals have generally the largest chests. More air also is consumed during great exertions than while the body is at rest; and death by suffocation is followed by a complete exhaustion of muscular irritability.

The mechanism of the respiratory function admits also of some varieties, influenced by the relation of the animal to the respired air.

The structure of the lungs in the animals which breathe air directly from the atmosphere, is formed by an union of the pulmonary vessels, the bronchial vessels, and the ramifications of the windpipe. In the gilled animals the latter system is totally wanting; because the gills floating in water, and abstracting from it the element of respiration, stand in no need of such an apparatus.

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* Rapports de l'air avec les ètres organizés, redigés, par J. Senebier,

In the animals of high respiratory powers the divisions of the wind-pipe are exquisitely minute, and the air-cells consequently numerous; their aggregate surface is perhaps greater than that of the whole body. The general appearance of the organ is cellular and spongy. In the cold-blooded animals, on the contrary, the lungs are vesicular, consisting of much larger divisions, and affording a surface proportionately smaller for the contact of the atmosphere.

In the class mammalia the cavity of the chest is totally excluded from the external air, and it is separated from the abdomen by a broad muscle called the diaphragm, whose movements tend to enlarge and contract alternately the size of that cavity. When the chest is thus dilated by the contraction of the diaphragm, a vacuum would be formed, if the external air rushing down the wind-pipe did not expand the lungs, and re-establish the equilibrium. When the diaphragm again relaxes, the elasticity of the walls of the chest, and the pressure of the abdominal muscles expel the superfluous air, and force the lungs to resume their former collapsed condition. By the alternation of these movements a continued supply of air is brought to the blood, during its circulation, through the pulmonary vessels.*

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* Dans les inspirations ordinaires, qui se font doucement et

In certain diseases, and under the pressure of great exertions, when it becomes necessary to make a deeper inspiration, the capacity of the chest may be still further dilated by an increase of its diameter, from the spine to the breast bone. This is effected by the action of every muscle capable of elevating the ribs. The laboured contractions of these organs, in cases of extreme dyspnœa, impress a very marked character of distress and agony upon the patient.

The respiration of birds is effected by a mechanism, in some respects similar to that described in the last paragraph. In order that the air may have a free passage to the air-cells, distributed through all the cavities of the body, the lungs are pierced by several holes. No change in their contained air can therefore be effected by the dilation of their cells—a diaphragm is consequently useless, and does not exist; and inspiration is effected by a movement of the chest itself, which is of a very large size. In the act of respiration, the thorax is elevated by its muscles, and the abdominal cavity is proportionately enlarged: a vacuum is thus formed,

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sans effort, le diaphragme agit presque seul, et sa contraction est suffisante à peu de chose près, pour augmenter convenablement la capacité de la poitrine.

Cuvier Leçons, T. iv. p. 357.

Cuvier also teaches that expiration is assisted by the elasticity of the air-tubes; and by a muscular contraction of their coats; but the fact cannot be tried by the test of experiment, and does not appear necessary to the explanation of the phenomena.

and the external air, rushing through the windpipe, permeates the lungs, and passes forward into the abdominal air-cells. The subsequent depression of the chest, by squeezing the abdominal cells, forces a current back through the lungs; and thus their air is perpetually renewed, and the aëration of the blood effectually secured.*

The respiration of frogs is effected by a process precisely similar to that of deglutition: a mouthful of air being first swallowed and then returned back again by the pressure of the abdominal muscles. The animal is suffocated if his mouth be forcibly kept open, because deglutition is impossible in that condition; the frog therefore breathes with the jaws accurately closed, and inspires only through the nostrils.

The respiratory organs of insects, it has already been stated, are diffused throughout every part of their body. They communicate with the external atmosphere through tracheæ, which open on each side of the animal at the several joints of the abdomen. When any of these orifices are stopped with oil, the parts which they supply with air become paralytic. The crustaceous animals are provided with regular lungs or gills.

The importance of respiration was not overlooked by the ancients: but the nature of its specific results could alone be appreciated through the assistance of modern experimental investigations. The language of antiquity is strongly tinctured with a philosophy in which air plays a most conspicuous part. Hippocrates observes that air forms a portion of the nourishment of the body, and is the pabulum of fire. He infers likewise its presence in water as necessary for the support of life to the aquatic tribes;* a fact that was first demonstrated by Boyle, through the instrumentality of the air-pump. With this apparatus Boyle further proved that the same portion of air would not serve indefinitely for the respiratory function; but that animals died if it were not rapidly renewed. This fact he attributed to a change in the mechanical properties of the air, which unfitted it for respiration; but later writers, by an happier conjecture, referred it to some unknown alteration of its chemical composition.†

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* Cuvier. John Bell.

From the time of Willis and Mayow, notwithstanding that the period includes the labours of Haller and Boerhaave, no increase of knowledge was obtained on the subject of respiration; until Priestley and Scheele, by their immortal discoveries in chemistry, threw a burst of day over the whole horizon of science, and caused a revolution in almost every branch of natural philosophy. By the experiments of these authors, and of their fellow labourers, Lavoisier, Black, Berthollet, &c. &c. the atmosphere was found to contain two invisible elastic fluids, of which one only (oxygen) is capable of supporting life, and of maintaining fire. The other portion (nitrogen or azote) produces, when breathed alone, immediate suffocation.* This analogy between life and fire, so long the subject of metaphor, was found to be the more just, inasmuch as in both processes the oxygen combines with carbon, and produces carbonic acid.

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* *Ὁυ γὰρ ἄν πότε τά πλωτά ζῶα ζωείν ἐδυνάτο, μὴ μετέχοντα πνεύματος.*

Hippocr. de Flat.

† Willis. Meade on the Plague, Chap II. Mayow, &c.

Since the period of these discoveries, the subject has been more minutely examined by a multitude both of chemical and of physiologcal experimentalists; but with a success by no means proportionate to the zeal and ability employed in the examination. In every thing that concerns vital action, there are so many points to consider, so many discounts and allowances to be made, before the result of experiments can be obtained with purity and precision, that almost every writer has given a different sum total to his labours. The chemist is not necessarily a good physiologist, nor the physiologist an accurate experimenter; so that it is rare to find a person uniformly well qualified to discuss the questions which arise in these investigations. But as every one relies on his own observations, theories have been formed, by an abuse of induction, from the partial results of individual enquiry, by almost every author who has written on the subject. The more, therefore, it has been laboured, the greater has become the necessity for repeating experiments, and the more vexatious the loss of time occupied in clearing the ground, preparatory to the erection of newer edifices.

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* Besides oxygen and azote, the atmosphere contains about $\frac{1}{000}$ of carbonic acid, which, however, in that state of dilution, does not effect respiration.

All writers are agreed that the principal end of respiration is the abstraction of carbon from the blood, which is expired in combination with the oxygen of the atmospheric air, under the form of carbonic acid—but,

It is disputed whether the oxygen be absorbed into the blood, and the combination with carbon effected within the vessels; or whether the carbon is secreted, and the combination effected in the air-cells.*

It has likewise been debated whether other chemical combinations may not take place in the lungs. The early chemists,† in examining this subject, conceived that more oxygen disappears during respiration, than is sufficient for the formation of the carbonic acid, resulting from the operation; and this they thought was expended in uniting with hydrogen, and forming water, which, as they taught, is exhaled in the form of moisture.

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* Ellis on respiration.

† Crawford. Lavoisier. Davy.

Later writers, though not agreed upon the relative proportion of oxygen and carbonic acid, are disposed to doubt that any combination takes place between the oxygen of the air and the hydrogen of the blood.* But the French physiologists, with Cuvier at their head, still maintain the opinions of Lavoisier on this subject.

Another question, connected with the supposed formation of water in the lungs, by the chemical union of oxygen and hydrogen, relates to the disappearance of a proportion of respired air; which was accounted for by the diminished bulk of the moisture thus formed. This imaginary loss, which received the sanction of Sir H. Davy's authority, has been explained by more recent experimentalists as proceeding from the difficulty, or rather the impossibility, of bringing the lungs at the end of an experiment to the same state of expansion, at which the process was commenced; and in confirmation of this view, it was determined that the loss of bulk bears no proportion to the duration of the experiment, or quantity of air passed through the lungs.

With respect to the azotic portion of the atmosphere, Davy and Priestley assert that a quantity disappears, which the latter estimates at something more than five cubic inches in the minute; but other writers,* of high reputation, maintain that no such loss is discoverable. Although this the largest portion of the atmosphere exerts no direct influence upon the pulmonary tissue, yet it should seem of material importance, in giving a due degree of dilution to the whole compound. Notwithstanding some contradiction in the experiments of Lavoisier, there can be no doubt that the respiration of pure oxygen gas cannot long be continued, without producing disease; and every analogy warrants the assertion, that if an atmosphere of this gas were thrown round the world, the organized species of nature would either perish, or submit to changes totally destructive of their character and identity.

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* Bostock on Respiration.

The principal change, which the blood undergoes in the lungs, is the loss of carbon; it should seem therefore to follow, that the change effected upon it in the systemic capillaries depends on the addition of carbon; a fact, which, if granted, cannot be satisfactorily explained. To meet this difficulty, it has been imagined that the oxygen passes into the circulation, traverses the arteries in a state of loose combination with the blood, and enters into an intimate union with carbon only when it arrives in the systemic capillaries.

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* Lavoisier, Vauquelin, Spallanzani, Ellis, Messrs. Allen and Pepys, all agree in denying the disappearance of azote, and their opinion seems likewise to accord best with the result of general reasonings.

On this theory, respiration consists in two distinct processes, the absorption of oxygen, and the exhalation of carbonic acid, formed during the conversion of the vermilion into purple blood.*

This, and other similar explanations of the phenomena of respiration, lie under the obvious objection of being *too chemical;* the agency of vitality is not sufficiently taken into the account. It is not upon pure chemical elements that the air acts, but upon the living compounds, whose real constitution is itself unknown. The conversion of arterial into veinous blood is a process involved in the deepest obscurity. It is certain that nothing is added to the mass in that part of the circulation where this change takes place; whether any single element be *abstracted* there, or whether the alteration depend upon a change of disposition in all the elements among themselves, cannot even be guessed. On the side of the pulmonary capillaries, it is demonstrated that carbonic acid escapes, and that a proportionate quantity, or nearly so, of oxygen gas disappears. Beyond this fact, nothing can be affirmed with any confidence on the subject; and the several theories that have been offered can only be considered as plausible explanations, adapted to appease the imagination, but not calculated to satisfy the judgment.

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* Hassenfratz, &c.

It has been estimated that something more than six ounces and a half of carbon are consumed by respiration in the twenty-four hours,* and that three grains of moisture are exhaled in a minute, making 4,320 grains, or little less than ten ounces, in the day and night.† But the application of numbers to vital processes can only be relied upon as approximations to truth, since the rate of function varies with every variation of stimulus. More air is consumed during exercise and after a full meal than during quietude and abstinence.

To the theory of respiration has been connected another series of phenomena, which relate to the preservation of animal temperature; and their explanation also has been sought in the principles of modern chemical philosophy.

All living beings have a prescribed range of temperature, within which alone they can perform their functions; and as they are more or less exposed to the variations of heat and cold, incidental to climate and season, they are endowed with powers of resistance to these causes, adequate to their individual necessities.

The range of temperature, within which organic beings preserve life and motion, is more extensive in vegetables and in the lower class of animals, than in those species which are nearly allied to man; and they follow more closely the variations of atmosphere. Trees, however, if examined during intense frosts, will be found to preserve a temperature somewhat above the freezing point; and the plants of the genus *arum*, at the time when the flower bursts its sheath, emit from the spike stalk which supports the organs of fructification, a degree of heat, considerably above the human temperature; an effect not the less singular for the suddenness with which it takes place, and for the shortness of its duration.*

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* Bostock. † Murray, Abernethy.

The temperature of birds is usually somewhat higher than that of the mammalia. The interior of the human subject is ordinarily below 100° of Farenheit's thermometer; though, in some febrile diseases, it has been observed to mount up to 109°†

The heat of the lower animals is seldom many degrees above that of the medium in which they live; and they are therefore designated as *cold-blooded* animals.

In a state of vigour and health, season and climate make but a trifling variation in the human temperature. In the burning plains of Africa, and under the rigours of the polar sky, the animal heat remains unaltered. Duhamel, indeed, found by experiment that in the heat of an oven, in which meat was baked, the living subject experienced only a very slight increase of temperature. These facts have never been satisfactorily explained: the ignorance in which we are placed respecting the real nature and origin of the phenomena of fire itself, places an obvious bar to the knowledge of the affections of organized beings by that cause.

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* Hubert examined the Arum Cordifolium. The spadices, which had burst on the preceding evening, exhibited a temperature twenty-five degrees above that of the atmosphere. On the following morning, it had fallen to twenty-one degrees; and in the evening to seven degrees. The site of the male organs was thirteen degrees higher than that occupied by the female. The external surface of the spadix is the seat of the process, which requires the presence of air, and is attended by an evolution of carbonic acid. La Marke discovered the same phenomenon in the common hedge plant, *arum maculatum* (Lords and Ladies).

† In scarlet fever.

The first person, who made any real addition to this branch of science, was Dr. Crawford, who, reasoning upon the then newly discovered laws, which regulate the temperature of the gases, was disposed to refer the animal heat to respiration. It had been demonstrated that bodies in general are affected in their temperature, as if by the agency of a peculiar material cause, which produced phenomena proportionate to the quantities in which it may be present. This supposed substance has obtained the name of *caloric.*

The phenomena of temperature also indicate the presence of this cause under two distinct modifications. In one of these it seems to remain chemically united to the body in which it exists, so as to exhibit no sensible effects to the observer, whence it was termed *latent* caloric; in the other it appears to subsist free, or loosely united and mixed only with foreign bodies, so as still to exert its sensible agency, and to communicate to those bodies the properties by which it is itself distinguished. This last modification has obtained the appellation of *sensible heat.*

Latent heat, by combining with foreign bodies in different doses, determines their existence in a solid, fluid, or gaseous form: different bodies require very various quantities of caloric to produce in them any definite alteration. The power of thus absorbing, and masking a determinate quantity of caloric, is termed the capacity for heat.

Sensible heat has a tendency to diffuse itself equally among all substances within the sphere of its action; and in passing from one to another, it produces in them those changes which are appreciable by our senses and by the thermometer. It requires very different quantities of caloric to raise different substances to the same thermometrical temperature; those bodies which have the smallest capacity for heat being the most extensively affected by a given dose.

Solid bodies, at the point at which they become fluid, and fluids, when they assume the gaseous form, suddenly acquire a vast increase in their capacity for caloric; and every change in the density of a body is accompanied by a corresponding change in its capacity. Equal weights of boiling water and of water at the freezing point being mixed, will assume a temperature very nearly the mean between the two extremes, a temperature which is represented by 122 degrees of Farenheit's thermometer. But a mixture of equal parts of boiling water and of ice will be reduced to 32 degrees. The ice will melt, and the whole additional heat of the boiling water will disappear to combine with it, and to satisfy its increase of capacity on assuming the fluid form.

From this fact it follows, that when bodies pass from a solid to a fluid, or gaseous form, those substances by which they are surrounded are cooled; and vice-versa, when a gaseous or fluid substance becomes solid, heat is evolved, and the temperature of the mass is raised.

Proceeding upon these data, Dr. Crawford discovered that the volume of carbonic acid gas, &c. expired by the lungs, has a smaller capacity for heat, and consequently contains much less caloric than the oxygen which was inhaled. According to his calculation, two thirds of the whole caloric of the oxygen is thus evolved in the respiratory process; and this he concluded must be communicated to the blood, during aëration, and thus must necessarily tend to raise its temperature.

On the other hand he discovered that vermilion blood has a capacity greater than purple blood, in the proportion of eleven and a half to ten. According to calculations founded on these facts, it appears that if the blood during aëration did not so receive caloric from the air, it would suffer a diminution of temperature, sufficient to reduce it 104° below the zero of Farenheit. Between these two circumstances there is a wonderful agreement. Heat is given off in the lungs from the air, sufficient to destroy the subject, if some means did not subsist for its instant removal; and on the other hand heat is absorbed by the aërated blood, in such quantities as would prove instantly fatal, if the supply were not at hand in the evolution of caloric from the oxygen.

Thus then, in a few words, may be expressed the Crawfordian theory: oxygen gas, in its conversion into carbonic acid gas, loses two thirds of its latent heat, while the blood during aëration increases its capacity for caloric; there is in consequence a transfer of this agent between the two substances with *little or no developement of sensible temperature in the lungs.** But the red blood, in re-assuming its purple condition, suffers a diminution of its capacity; the caloric acquired in the lungs is thus rendered sensible; and being distributed over the whole body, affords to each particle sufficient heat to raise it to the standard, consistent with vital action: the capillaries of the nutritive system are therefore (according to this theory) the immediate seats of animal heat.

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* It is singular, as Murray has observed in his system of chemistry, how frequently this point has been overlooked by physiologists. "Si la chaleur vitale tirait sa source unique des poumons, elledevroit être dans ces organs incomparablement plus forte qu'elle ne l'est par tout ailleurs; et l'activité de cet embrassement, necessaire pour échauffer tout le corps, iroit à détruire la substance des parties qui en seroient le foyer."

Damas, principes, t. iii. *p.*555.

'The same objection has been made by La Grange and Hassenfratz, who ought to have better understood the doctrine of specific heat.'

The simplicity of this explanation, the closeness of the reasoning, and the air of elaborate calculation and experiment with which it is surrounded, have rendered the Crawfordian theory universally prevalent; and it has long been taught in the principal schools of Europe. Of late years, however, it has been vigorously attacked. Mr. Brodie in particular having continued respiration artificially in a recently killed animal, without maintaining the temperature of the subject, has led many persons to a conclusion that the whole theory is false. The inference however does not flow from the premises, since in the artificial respiration no proportion can be observed between the quantity of air forced into the lungs, and the quantity consumed in the formation of carbonic acid; so that a vast quantity of caloric may be carried off when more cool air is injected, than is necessary for function.

The principal objection, which has been made to the Crawfordian theory, is founded upon some valuable experiments tending to prove that the evolution of heat is the result of an action which is performed under the guidance of the nervous system: but the admission of this fact rather corroborates than invalidates the chemical hypothesis. That theory simply affirms that latent heat is absorbed in the lungs, and given out in the general capillaries; while it is universally admitted that the quantity of caloric, thus liberated in any organ, is proportionate to the force of the circulation, and consequently to the intensity of vital energy; and that the calorific phenomena are concomitant with certain changes impressed by the solids on the circulating fluids. The only differences therefore that the new facts make in the Crawfordian theory, are a greater degree of precision in estimating the vital causes, which produce the chemical appearances, and the additional information that caloric is not only evolved during the purpurization of the blood, but in all the different changes which the vascular system can impress upon the circulating fluid.

By the Crawfordian theory the escape of superabundant heat is explained by the evaporation of perspired fluids, which doubtless would produce a considerable reduction of temperature; but perhaps this is the least pérfect part of the hypothesis, as it lies open to many objections. The power which animals possess of resisting excess of caloric is perfectly inexplicable.

Upon this point the Crawfordian theory must only be admitted for as much as it is worth ; and it must be remembered that animals which do not copiously perspire, exhibit the same powers of resisting temperature. Some diminution of excessive temperature may be attributed to the exhaustion of vital energy, which excess of caloric in the system produces ; an exhaustion which must diminish or suspend those capillary actions, by which the animal temperature is raised above that of the surrounding atmosphere: but the power which preserves the heat of an animal at the healthy standard, when exposed to the temperature of an oven, must be far greater than can arise out of any or all of these causes, and appears to indicate the existence of a law of calorific action, with which we are as yet unacquainted.

The vast and general analogy between the respiratory powers of animals and their habitual temperature, cannot be overlooked, in considering this question ; and it must afford grounds for a considerable leaning towards Dr. Crawford's views. But the laws by which heat is propagated, are too little understood to warrant any decided affirmations. There are not wanting many highly respectable authorities, who deny the existence of a material cause for the phenomena of caloric ; phenomena which they explain by certain unknown and undefinable vibratory motions, of which all sorts of matter are supposed to be susceptible.

Without entering upon this subject, it is to be observed, that besides the instances of latent and sensible heat, already noticed, caloric is elicited by friction and by percussion, (as in the common experiment of hammering a nail till it becomes red hot) and it is developed in electric and galvanic experiments, in quantities which admit of no explanation on the supposition of its having been latent in the subjects of the experiment. It radiates also from heated bodies, by a mobile power, peculiarly its own; and may perhaps be governed by other modes of excitement, with which we are unacquainted, and which may connect it with the exertion of living energy.*

On the whole, therefore, the Crawfordian theory, though imperfect and insufficient, is not necessarily fallacious, and it will still continue to have that weight which is due to the closeness of its inductions, and the number and accuracy of its experiments and observations.

The relation between life and respiration is totally obscure; that it does not consist in the mere giving off of carbon is evident, from the fact, that plants, while acted upon by light, absorb large quantities of this substance from the air, by the decomposition of carbonic acid. Thus while animals are converting a portion of the oxygen contained in the atmosphere into carbonic acid, the vegetables, by a contrary process, are restoring oxygen, and destroying carbonic acid.*

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* The generation of heat by percussion and friction, bears a striking analogy with the developement of electricity by the common machines.

With those reasoners who admit a material cause for life, that element has been supposed to exist dissolved in the air, or to be the air itself. It seems however more probable that the influence of respiration does not consist in the addition of any unknown principle to the system; but in an alteration in the constitution of the fluids. The manifest connection of living energy with temperature, and with developement of respiratory function, leads to an idea, that heat is the specific bond of connection. Many substances, which contain hydrogen and carbon, (elements highly inflammable,) are remarkable also for their power of exalting the sensibility of the animal tissues: and in general the most mobile and active elements, oxygen, hydrogen, carbon, nitrogen, light, and electricity, are predominant in vital combinations. The cooperation of heat, as essential to life, is a notion so universal and so ancient, as to seem almost instinctive. All these speculations, however, are mere reveries, and the immediate influence of respiration on life is yet to be sought.

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* This harmony does not however seem necessary for preserving the purity of the atmosphere, which appears to result from meteoric phenomena, conducted upon a much larger scale. The animal existences bear too small a proportion in creation, to influence very largely the constitution of the atmosphere.

Of the several Secretions.

Under the generic term of *secretion* may be included every instance, in which a part of the blood escapes from the circulation for the use of the economy, whether its chemical properties be or be not changed in the operation. In this extensive sense of the word, it embraces the phenomena of nutrition, of which there are as many varieties, as there are tissues to be nourished.

More usually, however, the term *secretion* is confined to the formation of fluid substances; which either perform distinct functions in the machine, or are separated for the mere purpose of elimination.

Anatomists and physiologists have established three principal varieties of secretion: 1st, *exhalation*, in which the more fluid parts of the blood are eliminated, without any material change in their properties; 2d, *the secretion from mucous follicles;* and 3d, *glandular secretion.* These distinctions do not however appear well founded.

In order that they should subsist, it would be necessary to establish a difference in the mode o action, in each subdivision: but as the intimate nature of secretion is not known, still less are there ascertainable generic differences, by which its instances can be subdivided. Every distinct secretion is the product of its own peculiar tissue; and there are no parts in the economy which exhibit greater differences among each other than the glandular tissues.

The mucous follicles are small glandular bodies, embedded in the substance of the mucous membranes, which secrete the peculiar fluid that lubricates those surfaces. In their arrangement they are indeed more simple than other glands; but their intimate structure and functions seem precisely the same. Neither is the distinction between exhalation and secretion better founded. Some authors indeed are of opinion that exhalation is a process nearly mechanical,* a porous exudation produced entirely by the *vis a tergo*, in which the solids are purely passive. That this however is not the case, is rendered evident by the phenomena of disease. In dropsy, not only the quantity of exhaled fluid is increased, but its quality is very materially altered; an alteration that can only be referred to a corresponding change in the vitality of the vessels from which it proceeds; and must be independent of causes merely mechanical.

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* Magendie states this position distinctly.

Malpighi, and the older anatomists, were inclined to ascribe the differences of secreted fluids to mechanical varieties of structure in the glands; and they imagined that they had detected the existence of follicles in those organs, by means of the microscope. But later writers agree with Ruisch in allowing nothing more to glandular structures, than is found in the nutritive parenchyma of other organs; namely, an artery, a vein, and a secreting vessel.

The peculiar nature of each secretion, far from depending upon mechanical causes, arises out of the specific vitality of the part; and it varies extensively with the varying sensibility of the organs, in their diseased and healthy state. Glands are parts of highly developed sensibility; and are, therefore, peculiarly subject to disease. Their secretions are constantly varying in quantity and in quality, and their substance is peculiarly liable to morbid changes, producing the most unmanageable diseases.

Under the term gland (a term of very imperfect definition) parts are included, which have no apparent connection with secretion;—such are the thymus (an organ of considerable size during infancy, but which degenerates as life advances), the spleen, &c., &c. There is also a large class of bodies connected with the absorbent system, which, though included under the common appellation of gland, differ in every respect from the instruments of secretion. These are the *lymphatic glands.* They occur in various parts of the body in the course of the absorbents. By some writers they are regarded as mere convolutions of those vessels; but their structure and use are alike involved in mystery. This absurd misapplication of the term to bodies so little allied, is a dangerous source of error to the general reader, and is not without inconvenience in professed anatomical description.

Of the several glandular structures, those which are subservient to the nutritive functions are of most regular occurrence, and follow most closely an architypal model. All cavities, which admit the contact of unorganized or foreign matter, are lined with mucous membranes, whose secretion assists in defending the living solids from the injurious impression of foreign bodies, which may be brought in contact with them. This they effect by involving the too stimulating matter in mucus, and thus removing it from a close contact with the sentient tissue. It is a general law that a certain increase of stimulation excites all secreting surfaces to a more copious discharge of their peculiar fluids; which, at the same time, become not unfrequently thin, watery, and imperfect. They thus operate in washing off, and mechanically removing irritants, whose stimulating power they cannot obviate. A speck of dust in the eye produces a sudden gush of tears, by which it is removed from the eye-ball. Snuff produces the same effect in the nose of persons, unused to its stimulation. The blister-fly, when applied to the skin, causes a secretion of serous fluid, which, by raising the scarf skin, interposes itself between the irritant and the true skin beneath. The same, also, is the mode of action of cathartic and emetic drugs. This law, which is so serviceable, when the cause of irritation is present in substance, becomes highly inconvenient, and even fatal, when the exaltation of vital energy in these parts, depends rather upon a change in their sensibility, than upon the presence of unusual stimuli: dropsies, humoral asthmas, diarrhœas, and many other hideous and destructive diseases are the consequences of this combination of circumstances.

Internal cavities, which have no communication with external nature, are lubricated with a serous exudation, which, in the healthy condition, is absorbed as fast as it is formed.

Of all the secretions subservient to the nutritive functions, the urine is of the least general occurrence. It is confined exclusively to the vertebrated animals; and is abundant only in the species of the class mammalia. In its character this fluid is purely excrementitious; being not only useless, but detrimental to the economy.

The constituents of urine hang together by loose affinities, and it is decomposed immediately on quitting the sphere of living action. On first leaving the body, it is sensibly acid; but speedily becomes alcaline, by the decomposition of the quadruple animal compounds, which it holds in solution: the nitrogen and hydrogen forming ammonia, which super-saturates the remaining acid ingredients.

The apparatus for the secretion and elimination of this fluid is extremely complicated. Being one of the last efforts of organization, it seems to partake of the imperfections, which, both in organic and mechanical combinations, attend the most elaborate arrangements.

The kidney,* or gland by which this fluid is secreted, is, by an inexplicable caprice of nature, placed high up in the loins, and communicates with the bladder by long slender tubes, termed *ureters*. The delicate play of affinities, by which the secretion is formed, renders it singularly liable to be deranged; when the peculiar substance, termed gravel, is formed, which, from this position of the kidnies, is rendered infinitely more painful, troublesome, and dangerous, than if the passages were otherwise contrived. It is in vain to dissimulate; the gravel and stone are diseases, the immediate consequences of an awkwardness in the mechanism of the organs; an awkwardness doubtless *necessary*, because it exists; but, in as far as it operates, incompatible with the well-being of the individual, and often destructive to its existence.

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* Connected with the kidnies in situation are two bodies of an apparently glandular structure, called atrabiliary capsules, rènal glands, renes succenturiati. They have no visible excretory ducts, and have apparently no other relation with the urinary system than that of vicinity.

The whole of the urinary system is lined by a mucous membrane, which has no connection with that of the alimentary canal and thorax, but which still exerts considerable sympathetic influence over it.

The different constitution of the urine, under different circumstances of the constitution, affords another argument against the division of exhalations and secretions. At times it contains only the watery and saline constituents of the blood, pure and unchanged: at other times its constitution is elaborate and complicated. Occasionally, even the blood passes in substance from the kidnies, without any rupture of blood-vessels.

These differences in the urine are the most remarkable at the periods of fasting and of repletion: violent mental agitation, also, produces an abundant secretion of pale, watery urine, which is formed with an inconceivable rapidity.

In its relations to the general economy, this secretion seems to be supplementary to very high powers of animalization;[*] being destined to remove the hyper-organized matter, which, if allowed to remain in the circulation, would necessitate the decomposition of the blood.

There is a material difference in the urine of carnivorous and herbivorous animals. In the former, the prevalence of azote gives origin to a peculiar substance termed urée, which, together with the uric acid formed from it, exists abundantly in their urine. In the herbivorous animals the benzoic acid prevails, and the uric is deficient.

The peculiar character of this fluid explains the danger incidental to its extravasation into the cellular substance, or abdominal cavity; and accounts for the violent train of symptoms which supervene on the suspension of its secretion. Of all the natural secretions, this is the most remote in its character from the blood and living solids. Its presence, when extravasated, operates as an irritant of the highest acrimony; and gangrene, or mortification, speedily follows its action in unnatural situations.

The suppression of this secretion, if it subsists but for a short time, overloads the circulating fluids with hyper-animalized matter; which, while it stimulates the solids to inordinate action, is itself prone to decomposition; and thus deranges the chemical constitution of the blood, and excites febrile action.

The secretions, which are connected with animal life, are more varied and peculiar than such as belong to the nutritive functions. Thus, though the mucous membranes of all animals secrete nearly the same fluids in the similar organs, the skin, on the contrary, which in structure and in function so closely resembles the mucous tissue, exhibits differences in its secretions, analogous to the varying habits of the different species.

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[*] Fourcroy.

In those tribes of animals which are cased in an hard, tough envelope of epidermis, to shield them from the external violences to which their habits of life expose them, the secretion of the skin is very limited, or even in total abeyance.

In fish, and such animals as live habitually exposed to the watery element, the natural secretion of the skin is more or less oily; or resembles very closely the true mucous secretion.

The soft skinned animals, which perspire, secrete from the skin a fluid that varies in its character under different circumstances. The experiments of Sanctorius first proved the transpirations of an immense quantity of fluid, under the form of an invisible vapour. When the skin is stimulated by heat, and by the action of some drugs, this secretion may be collected in a fluid form. It is an aqueous liquid, slightly acid, and is mixed with small portions of oil, secreted by minute glandular bodies, embedded in the cuticular tissue. The quantity of perspired fluid varies inversely as the secretions from the mucous membrane of the intestines, and from the kidnies,—especially the latter.* In close, over-heated, and crowded apartments, the condensed perspiration emits a sensibly urinous odour; and it is not improbable that, under these circumstances, the fluids secreted by the kidney are re-absorbed and eliminated by the skin. Instances are on record of the secretion of Prussian blue by this surface,† which is a compound of iron, and a peculiar animal acid, analogous in its constitution to the urée. Like the urine, the perspired fluids undergo changes in particular morbid conditions, which, however, are chiefly indicated by their scent.

From these facts it may be concluded, that perspiration is a function supplementary to, and vicarious of the secretion from the kidnies; on which account, perhaps, it should be classed among the secretions dependent upon the nutritive system.

Many secretions belonging to the system of relative organs are connected with the mechanism of the parts; as the cerumen of the ear, the lacrymal fluid of the eye: the existence of the glands by which these fluids are secreted, depends upon that of the organ, to which they are subservient.

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* In pulmonary consumption the alternation of profuse perspiration with colliquative diarrhœa forms one of the most unmanageable and destructive symptoms of the disease.

† Abernethy.

Some secretions, likewise, arise out of the moral or physical necessities of the animal; such as the poison of the viper for attack, and the fœtid exhalations of vermin for defence. These secretions are in relation, the one with the habits of the animal, as being carnivorous; the other, as respiring the air. A poison bag would be useless to the serpent if it fed on vegetables; the fœtid secretion of vermin could not be disseminated, if secreted by a marine animal. On the other hand, the inky secretion of the cuttle-fish, which that animal employs as a means of baffling its enemy, and escaping pursuit, derives its utility from the circumstance of its being diffusible through water. There is a little insect termed the bombadier,* which, when pursued, emits, with an explosive noise, a bluish, acrid vapour, very highly irritating to the senses of its enemy; which is an insect of the same tribe, but of three or four times its size and force. To this singular apparatus the last observation equally applies; as it likewise does to the oily secretions, proceeding from the rumps of water-fowl, with which those animals smear their feathers, to protect them from the influence of moisture. These and other similar secretions, depending upon peculiar contingencies, could not exist universally, without deranging the economy of the larger number of species; they would, if not thus circumscribed, involve incompatibles; and if the fertile womb of nature could give birth to such combinations, the organs would either be lost in a long series of generations, for want of use, or the species itself would disappear from the catalogue of organized existences. This law is evidenced in the paps of male animals, which being unconnected with those instinctive impulses, that arise from the female organization, are never fully developed, or thrown into that state of orgasm, which accompanies the secretion of milk. In the female subject the functions of this organ are excited by a peculiar condition of the womb: and as this link is wanting in the chain of male causation, the stories on record of men suckling their orphan children, are highly incredible. From the absence of this stimulus the male breast appears to have suffered a gradual diminution. The limits of recorded history are too small to afford accurate data, for noting the progressive changes which may have taken place in the organized species; but it is not improbable that, in the lapse of time, this organ may totally disappear from the male economy.

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* Carabus crepitans.—*Bingley's An. Biography.*

Of the Nervous Apparatus.

The circumstances which cause the necessity for a nervous organ are not very evident. In the whole of the vegetable kingdom, and in some of the lower animals, there is no trace discoverable of any such structure. It is not, therefore, essential to vital action.

The function most immediately dependent upon the nervous tissue is perception; which is uniformly most exalted in those species whose nervous apparatus is the most largely developed. Yet there is a considerable portion of this tissue (the sympathetic plexus) which is foreign to the business of perception; while, on the other hand, the bones and fibrous organs, which are apparently insulated from nervous influence, are, in certain morbid conditions, the seats of acute pain.

The specific nature of the functional action, in the nervous tissue, is too obscure to afford information concerning the necessities in which it originates. Almost all theorists have agreed in considering the nerves as the mere vehicles of some subtile and mobile agent; and some recent experiments lately published by Dr. Wilson Phillip seem to lead to the conclusion, that this agent is galvanic electricity. The original experiments of Galvani, exhibiting the capability of the galvanic fluid to imitate the action of the nerves on the muscular system, are well known. Dr. Phillip has proceeded one step farther, by shewing, that the influence of the nerves upon secretion, may likewise be supplied by the galvanic current. Hence he is led to conclude, that the agency of the vascular system is confined to the mere distribution of the fluids; while the chemical changes incidental to secretion are produced by electric shocks, transmitted through them by the nerves.

But if the general position be admitted, that the nervous system is a mere galvanic battery, some other instrumentality must still be sought, to explain the vast variety of substances produced from the same blood, in the different organs of secretion; and also to account for the secretions which take place in the vegetable kingdom, where no such apparatus as a nervous system exists.

If the entire series of animal species be examined, some proportion will be found to exist between the developement of the nervous tissue and the complexity and latitude of function of the general organization. In man and the higher orders of animals, the spinal marrow is greatly more voluminous than the nerves with which it is connected; and the brain is still larger than the spinal marrow. In the lower animals the brain becomes gradually smaller, and the spinal marrow therefore is relatively more developed. In the insect tribes, the latter organ forms only a slender cord, knotted at distances by enlargements of its substance, called *ganglions*. The superior ganglion, which takes the place of the brain, is scarcely distinguishable from the others, except by situation.

To these differences in the structure of the nervous tissue, there are no corresponding differences of function. Most animals see, hear, taste, smell and touch; nay, some of them may have organs of sense of which man can form no idea. They all likewise feel, or are conscious of the impressions of the senses, and re-act upon them in a congruous manner. On examining the organs of sense, we find indeed that they are not in the several species equally adapted in their mechanical arrangements for receiving the physical impressions of their specific stimuli. We must therefore conclude, that although the more imperfect animals receive the same impressions as the higher classes, they receive them in smaller numbers and in a less variety. Their volitions therefore must be motived by fewer causes, and these, from their very simplicity, must more rarely be placed in opposition to each other. They will consequently more seldom require that balancing in the intellect, which is called reason. Such animals must feel their impressions more forcibly, and go more directly to their end, than beings susceptible of influence from a greater variety of causes. But for all the rest, the series of phenomena, from the external impression to the consciousness, and thence to the volition and the muscular action, seem precisely the same, in the lowest as in the most perfect organizations.

From these considerations, it may be concluded that the existence and developement of the nervous system is regulated by the quantity and continuity of action, necessary to the permanence of the several species, rather than to any thing peculiar in their condition; and that its specific end in the system is the exaltation of living energy in the entire machine.

The functional action of the whole nervous apparatus being thus ill understood, it becomes still more difficult to assign specific functions to its several parts. The nervous system is generally divided by anatomists into the brain, (including the cerebrum and cerebellum) the medulla oblongata, the spinal marrow, and nerves; but as separate functions cannot universally be assigned to each of these parts, the division must be viewed as in a great degree arbitrary.

Perception, which constitutes the more immediate function of the tissue, being a vital action of great intensity, it requires not only a greater degree of living energy in its own appropriate apparatus, but also in the several instruments of nutrition, by which the whole economy is supported. The nervous tissue accordingly appears to exert a double action; one solely referable to the external world, and one connected with the internal organization. The nervous tissue is therefore more physiologically divided into the cerebral system, and that of the sympathetic plexus; and these parts are not less distinguishable for anatomical peculiarities than for the differences in their functional phenomena.

In proportion as that part of the nervous tissue subservient to perception is more developed, it becomes at the same time more concentrated; and its actions are more decidedly referable to a common centre. In the highest class of animals, in which the brain is the most perfect, the functional energy of the nerves depends upon their free communication with that organ. If a nerve be divided, or a ligature be thrown around it, all parts influenced by that nerve, below the seat of injury, become instantly palsied. Impressions made upon them are not perceived, nor can the will, as before the experiment, excite them to motion. Similar consequences follow like injuries done to the spinal marrow. But in reptiles, in which the brain bears a much smaller proportion to the spinal marrow, its influence is less essential. Animals of this and the inferior classes exhibit unequivocal marks of perception and of volition, long after the head has been decollated. The position therefore derived from human physiology, that perception is a function which arises out of the peculiar structure of the brain, and has its exclusive seat in that organ, is not tenable. It should seem, on the contrary, that the concentration of this faculty upon a particular spot in the nervous apparatus, follows a law analogous to the polarity of magnets; that as the fragments of a broken loadstone acquire, each of them, a new polarity, so the divided portions of the nervous tissue assume a new centre of action.* From this view of the subject, it should follow that perception is the result of a greater intensity of the same cause which produces the other nervous phenomena, and presides over the organic sensibility which is independent of nerves; and that the spinal marrow of the higher animals does not perceive after decollation, not because it wants the necessary construction, but because it is deficient in the requisite force.

There is, however, no part of the history of nervous apparatus more embarrassing than the subject of its separate functions. The appearances which the anatomy of this tissue exhibits, warrant the supposition, that the nerves of sensation and volition, the brain and spinal marrow, are perfectly alike in substance and arrangement; and physiologists in general are agreed in referring the different sensations, propagated by the several organs, to peculiarities in the terminations only of the different nerves. But notwithstanding this apparent identity of structure, and the possibility of perception being, under certain circumstances, seated in the spinal marrow, it is still the exclusive property of the nerves to feel, and the more peculiar province of the brain to perceive and to will. A slight pressure made upon the brain throws the animal into profound sleep, and obliterates the perceptive and voluntary faculties; yet the surface of this organ may be scratched or irritated by chemical stimuli, without exciting the attention of the animal.

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* Cuvier—Leçons, ii. 95.

If the galvanic theory could be deemed admissible, it might perhaps afford some key to the solution of this difficulty. If the entire apparatus be indeed a galvanic battery, each pair of nerves, with the portion of spinal marrow from which they arise, may be considered as a separate pair of plates, and the phenomena may be divisible, according as they result from the action of a portion of the battery, or from its united force. No mechanical divisions are indeed traceable, analogous to the plates of galvanic batteries; but neither does it appear that the galvanic current is produced in the nerves by the same means as in the artificial machine. On the other hand, Cuvier has remarked that, however similar in apparent structure, the different pairs of nerves are not equally subservient to the same purposes: the ear is never supplied by the optic nerve, nor the eye by the acoustic; and parts of similar function always derive their nerves from the same source, however remote from each other their situation in the body. Upon this hypothesis, perception and its several modes, volition, the influence of the passions on the several organs, the effects of extensive injury of the brain upon the general system, and (according to Dr. Phillip) the agency of the sympathetic plexus must be taken as resulting from the whole machine, and the individual actions of each particular muscle and organ, as proceeding from the function of their several appropriate nerves.

This theory is entitled to a more attentive consideration, from its agreement with anatomical appearances. Those parts which are under the dominion of the will, and convey to the percipient organ the impressions they receive from without. are supplied with nerves, which arise from determinate portions of the brain and spinal marrow. Between these definite portions of the brain, and the organ to which they correspond, the comunication is simple and direct; each particular nerve being a fasciculus of smaller nervous cords, running parallel to each other, and communicating distinctly between the two extremities. Every fibre of the body, which is under the dominion of the will, is thus placed in relation with a definite spot in the brain or spinal marrow, and volition may be conceived to operate upon it, through an action concentrated exclusively on that point.

But the nerves of the sympathetic plexus, which influence organs removed from the control of the will, are otherwise constructed. The sympathetic plexus consists of a network of nerves, uniting with each other in every possible variety, and also with numerous ganglions, or knots of cerebral substance, which appear to perform the functions of so many distinct nervous centres. This system of nerves unites with the brain, and with every portion of the spinal marrow, by numerous communications. It may therefore be considered as receiving impulses from all these points, and consequently as being susceptible of the joint influence of all, without being subjected to any specific affection from each. It is accordingly found, that the parts to which these organs are distributed, although emancipated from the dominion of the will, are subjected to the full influence of the passions and other causes, which act upon the whole nervous system.

In the present state of knowledge, it is evident that very little reliance can be placed in any positions respecting the nervous tissues, not founded upon absolute experiment, and the Spanish proverb applies to this subject with peculiar force: "De las cosas mas seguras, la mas segura es dudar." This much, however, seems to be demonstrated; that the nervous apparatus does not directly convey to the other tissues any principle or influence immediately necessary to their life; that it is not the seat or secretor of a vital fluid. The muscular structures not only exist in total independence of the nervous agency, but are capable of performing their contractions without its interference. The nerves of volition act upon the voluntary muscles merely as their appropriate stimuli; and those of the sympathetic plexus affect the involuntary muscles in some manner still more remote; and this perhaps is all that can be asserted on the subject.

The structure and arrangement of the nervous organs have occupied the attention of anatomists in all ages; and the minutest facts have been faithfully recorded; but physiologists have not yet succeeded, in connecting the appearances thus noted with corresponding movements or results. The proper tissue of these organs has by some persons been considered as glandular, by others as a mere mass of pulp;* but Messrs. Gall and Spurzheim have succeeded in demonstrating its arrangement to be fibrous; and that the fibres of different parts of the brain pursue different directions. The theory, however, which these speculators have promulgated, and which assigns distinct functions to the different portions of the brain, and ascribes to each a definite propensity, must at present be regarded as a mere *gratis dictum;* and as one also that is contradicted by the best ascertained facts in metaphysical science.

Although the relations of structure and function in the nervous organs be thus obscure, there exists a very manifest adaptation of the apparatus of relative sensibility to the physical properties of external nature, through the medium of the organs of sense. The eye, it is well known, is an optical instrument, resembling a camera obscura; by means of which an image of the objects, placed within the sphere of vision, is traced upon the optic nerve. There is also a further adaptation of the nerve itself to the subtilty and delicacy of the impetus of light: for the retina, or sensitive extremity of the optic nerve, is an expansion of nervous matter, soft, pulpy, and divested of its usual membranes, so as to be in immediate contact with the luminous rays.

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* Cuvier Leçons.

As the structure of the eye is adapted to the properties of light, so is the mechanism of the ear constructed to correspond with the vibratory elasticity of the air and other bodies, by which sound is propagated. Sapid and odorous substances are brought into contact with the organs of taste and smell by their solubility in the mucous secretions, exuding from the surfaces of those organs. The impressions of touch are purely mechanical, and the nature of the sensation which follows the impact of bodies, upon different parts of the organized surface, is regulated by the greater or less tenuity of the epidermis, or scarf skin interposed between the sentient tissue and the impinging substance, and by the degree of developement in the tissues themselves. The superior sensibility of the fingers' ends depends chiefly on this latter cause.

Besides these obvious mechanical differences in the organs of sense, there are other unknown vital peculiarities, connected perhaps with unknown structural varieties in the terminations of the nerves. If a slight shock of electricity be passed through the eye, an operation in which the mechanical apparatus of the organ is not interested, a sensation of light will be produced : whereas if it pass through the gustatory or olfactory nerves, the sensation will be a taste or a smell. This view of the subject is confirmed by comparative anatomy, which teaches that, notwithstanding those structural differences which fall upon the mechanism of the organs of sense, and which render the impressions made upon them in the inferior animals less accurate and discriminable, the sensations attached to each nerve of sense are still in their essence the same in all animals ; and produce in the meanest no less than the highest classes, actions congruous to their cause.

The necessities which preside over the several senses are likewise abundantly manifest. The necessity of touch is self-evident ; no animal destined to move upon the earth, could subsist without it. The utility of taste, both as a means of discrimination between articles of diet, and as an incentive to taking food, is no less intelligible. To this end the sense of smell is also subservient : and it is most highly developed in those animals which require a knowledge of the existence of their food, while placed at considerable distances ; that is to say, in the carnivorous species. Of the necessity of sight to self-preservation* it is unnecessary to speak: and hearing, a faculty adapted to the same end, is rendered necessary by the periodic absence of light, and by the existence of dangers which do not, like light, proceed uniformly in straight lines.

These necessities being common to all the higher classes of animals, in various degrees, the organs of sense in various states of developement are alike universal. When the habits of a species are unfavourable to the exercise of any sense, the organ seems in those animals to have dwindled in a corresponding degree: this is the case with the eyes of moles. The habitual use of a sense, on the contrary, appears to favour its developement. The hearing of timid animals is remarkably acute. The truth of this supposition is evinced by the corresponding differences observable between individuals of the same species. The senses of a savage are greatly more acute than those of a civilized man: the savage retains the power of moving his ears, which is lost among more polished nations: his nostrils are likewise more dilated. The increased delicacy of touch, in persons who have lost their eyes, is another fact, which favours the same doctrine.

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* Although some individuals subsist without the use of the organs of vision, it is evidently impossible that societies should do so.

In proportion as animals differ more widely from the human structure, the greater is the difficulty of determining the analogy of their senses to our own. In examining, however, the several species, we perceive them either to be or not to be influenced by certain impressions; and thence we deduce the presence or absence of the corresponding organs. In a few instances, important differences are discoverable in the general mechanism of the organs of sense; thus the eye of some insects is known to multiply objects of vision many thousand times; but the influence of this arrangement upon their mode of seeing is obviously unascertainable.*

Whether some animals may not possess senses, of which we can have no conception, is a proposition whose abstract possibility cannot be doubted; but as the power of conceiving the concomitant sensations, or the necessities with which they may be connected, is placed without the scope of our organization, there cannot be found data for determining the fact in the affirmative.

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* The surface of the compound eyes of insects exhibits a series of hexagonal, slightly convex faces, separated from each other by slight furrows, which are not unfrequently set with short hairs. But a still more singular circumstance, is the existence of a coat of black matter, analogous to the pigmentum nigrum of the human eye, which completely covers the inferior surfaces of these multiplied corneæ, and apparently precludes the further passage of the light. It is evident that the relations of this machine to the luminous pencil are not the same, as in a common eye; and it should appear, that the sensations it propagates, are of a different nature; since some insects exist, possessed of both instruments.

Muscles and Bones.

The organs of loco-motion are influenced by so many external causes, that the same subservience to one architype, which distinguishes the nutritive functions, is manifestly impossible.

In every situation, in which life can be supported, nature is replete with its products. The air, the earth in all its regions, the sea and fresh waters, the interior of living animals and vegetables, and their disorganizing remains after death, teem with animal existences; and the powers of movement in each, are adapted to the medium they are destined to inhabit, and to the exertions they are required to make for the preservation of their life.

The immense variety of structure, thus necessitated, may however be reduced to three primitive forms:—that in which the bony structure is placed *externally*, that in which it is *concealed beneath the soft moving fibres*, and a third in which it is altogether absent. The apparatus of loco-motion usually consists of three orders of parts:— 1st. A mechanical arrangement of firm, dense, unyielding organs, of little sensibility and obscure vitality. 2dly. A muscular structure by which motion is essentially performed: and 3dly. The nerves, by which the impulses of volition operate in determining the actions of the muscles. Between these parts a necessary harmony subsists: a complicated skeleton implies the existence of numerous muscles, and a degree of relative sensibility capable of receiving motives, and of exerting volition adequate to the extent and variety of its powers of motion.

In those animals which move *per saltum* a skeleton is absolutely necessary, formed of many pieces, and connected with numerous articulations. In those species, whose progression is confined to a trailing motion upon the surface, this mechanism is totally wanting.

In the insect tribes the levers and fixed points of motion are found in an external skeleton, or case, formed by a condensation and hardening of the skin, while the four highest classes of animals, the mammalia, birds, reptiles, and fish, are supported and moved upon an articulated assemblage of bones, which are placed within the soft parts by which they are moved.*

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* The solitary bone of the cuttle fish (which is used in the manufacture of *pounce*) may be considered as the rudiment of an interior skeleton. In this respect, as in many others, the genus sæpia seems to occupy the head of the invertebrated families, and to connect them with the superior classes possessed of articulated spines.

The general model, upon which this apparatus is framed, is the same in all; but it admits of some differences, arising out of the necessities of each separate species. In its most abstract outline, the skeleton consists of a spinal column, composed of many small pieces, termed *vertebræ*, pierced through their centre, so as to form by their junction a continuous canal, destined to contain the spinal marrow; an osseous case at the anterior extremity to hold the brain, together with the bony substructure of the face; in the middle the ribs and sternum, forming the cavity of the chest; and lastly, four combinations of bony levers, constituting the anterior and posterior extremities. These last are wanting in serpents, and in some fish. The hind feet are absent also in the cetaceous mammalia (whales), and in the apodal fish: the anterior extremity, in one species of lizard only. No vertebrated animal has more than four members, except the reptile called the flying dragon *(draco volans)*, which has a sort of wing, supported upon six cartilaginous rays, articulated with the spine.*

Of the bones composing the thorax, the sternum, or breast-bone, is wanting in serpents and fish; and the ribs also are absent in some species of this last class, and in the entire family of frogs. The head and vertebræ are universally present, though the latter differ in number, according to the length of the animal, and in construction, according to the motions requisite in the part where they are situated.

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* Cuvier.— Histoire des Animaux.

The reason of these differences is abundantly evident. The bones of the head and spine being adapted to receive and defend the brain and spinal marrow, are connected with the most important and indispensable organs in the animal economy: they are therefore constant. The thorax, on the contrary, connected with the function of respiration, must submit to modifications, founded upon the different modes in which that process is conducted: moveable ribs would be useless, for example, in the frog, which breathes by deglutition. The extremities, lastly, being calculated upon the medium the animal inhabits, and upon its necessities for loco-motion, must necessarily be the most variable parts, both in number and disposition, of the whole skeleton.

By a comparative examination of the skeletons of different animals, it will be found that the most imperfect differ from the most perfect, merely by *defect;* and that in the intermediate animals, the defective parts frequently exist in a state of degradation, forming, as it were, a connecting chain between the two extremes.

Thus the wings of birds afford an osseous structure, analogous to the wrist and hand; and so does the fin-shaped extremity of the whale tribe, although the motions for which, in the more perfect animals, these parts are constructed, are not thereby rendered possible. Another instance of this fact may be observed in the fore-arm of some animals:—In the most perfect, this member consists of two bones, but in a few species it is composed of a single piece: in these, however, the bone in question is marked by a furrow, or division, indicating an attempt at the more perfect formation. The great toe on the human subject is in like manner an abortive attempt at the thumb.

From these, and many other similar facts, it should seem as if, at the period in which organization commenced, there existed in nature a *nisus* towards a given mode of combination, which was more or less violently resisted by counteracting causes. Some speculators have regarded this similarity of structure, as a proof that organization commenced by the most simple species; and that by a progressive spontaneous developement, the more perfect animals were formed from them; in the same manner as the butterfly proceeds from the caterpillar; the organization of every genus being modified by the external circumstances in which accident had placed it.*

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* Those theorists who believe the earth to have been in the beginning uniformly covered with water, consider the aquatic animals as the parents of the land species—velut ægri somnia!

The structure of bone is analogous to that of the other tissues; that is to say, it consists of a reticulation of cellular substance, in which there is deposited the peculiar and appropriate matter of the bony tissue. This matter is the earthy salt, termed *phosphate of lime*. Its formation requires a considerable developement of vital force; and it does not take place in the early condition of the fœtus. Previous to the existence of the bones, their place is supplied by *cartilage*, an elastic substance, more familiarly known by the name of *gristle*.* The first step to the formation of bone is indicated by the appearance of a vessel upon the cartilage carrying red blood; this is speedily followed by the absorption of a speck of the original matter, and the secretion of a speck of phosphate of lime, from which, as from a centre, fresh bony matter irradiates, in all directions, by the continued action of new-formed vessels. In every bone, ossification begins from several of these centres; and continues till the different formations meet, coalesce, and consolidate into one entire piece. In some instances, however, these junctions take place only in advanced life—the line of separation is then called a *suture*. The law, which regulates this process, is very obscure.

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* This circumstance harmonizes well with the pressure which the fœtus sustains in passing into the world.

It commences rapidly in the latter periods of fœtal existence, and continues through life, gradually decreasing in vigour, (as far as the skeleton is concerned) and it seldom if ever supersedes entirely the cartilaginous tissue. On the contrary, the existence of cartilage in every part of the skeleton, where two bones articulate so as to allow of motion, seems a fundamental necessity; for without the interposition of this elastic, compressible matter, motion could neither be performed with grace nor with safety to the tender and delicate tissues, which are essential to life. Yet in advanced age the ossific process seems to assume an increase of intensity; but the cartilages are no longer the seats of this process. The ossification of these parts is rarely carried so far as to impede motion; though some surprising instances of this diseased affection of the joints are on record. The peculiar seat of the ossific action in advanced life is the internal coats of the arteries. According to the testimony of Bichat, in every ten subjects after the sixtieth year of life, seven, at least, exhibit traces of this disease.*

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* This is one of the effects of that solidification resulting from living action already mentioned. The valves of the arterial or left side the heart are frequently the seats of this affection; when considerable derangement of the circulation ensues. The osseous induration of the arteries, inasmuch as it is destructive of their

The vigorous exertion of living energy, which is requisite for the secretion of phosphate of lime, occasionally renders the effort too great for the constitution. A low degree of this vice constitutes the disease called rickets, in which the bones becoming unequal to support the weight of the body by the deficiency of earthy matter in their structure, bend and assume distortions, which eventually become permanent. More rarely the defect of phosphate of lime is so complete, as to render the whole skeleton, first brittle and then flexible; when the patient dies, from the injury sustained in vital parts, by the failure of support from the osseous organs. The bony tissue of fish is less solid than that of animals; and there exists a numerous family, in which the skeleton is permanently cartilaginous; a condition rendered supportable by the density of the medium these animals inhabit.

The form and position of the different constituent bones of the skeleton are regulated according to the laws of mechanics; and they form a series of levers, pulleys, and hinges, analogous to those existing in artificial machinery. In this respect, however, as in all others, vitality interferes and modifies, more or less, the details of arrangement.

In the combinations of artificial machinery, the

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elasticity, tends to the same disturbance; but is seldom sufficiently extensive to destroy life.

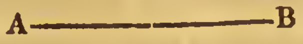
great object of the contriver is to obtain an increase of power: the several parts are so put together, as that each shall act upon the other, with a mechanical advantage. With respect to the lever, the great instrument of animal movements, this can only be effected by an excess of length in the moving branch, by which it describes round the fulcrum, a segment of a very large circle. The consequences of this arrangement in the animal structure may be easily imagined. Let any one suppose the bones of the leg to be articulated to those of the thigh *at their middle*, instead of their extremity: in the extended position of the limb the upper half of the leg would lap over the thigh; and when bent, it would form, with that bone, a right angle: a condition, utterly incompatible with the safety of the arteries and nerves, and totally destructive of grace and form in the limb. In most of the animal movements therefore the levers play at an enormous disadvantage, and this defect is counterbalanced by a corresponding increase of energy in the muscles. A great advantage is gained by this arrangement, in celerity of motion. If the branches of a lever are equal, no more space is traversed in a given time by the one limb than is measured by the other: but when a force is applied to the shorter branch of an unequal lever, it compels the longer to traverse in equal times a space which is proportionate to the circles of which the two branches are respectively the diameters.

By this law of mechanics likewise is regulated the relations of the separate joints which compose the limbs. Those bones which are placed nearest to the body in the limb, are long, and are so articulated as to allow of great latitude of motion; because all the movements communicated to these bones, are more intensely conferred upon those which are at the more distant part of the lever. The joints which are placed more remotely from the centre are not calculated for extent of motion, but receive it from the proximate articulations; and they are arranged rather for the production of complex and multiplied movements. The observations connected with this subject might be extended through many volumes; for the vast variety of movements which animals exhibit, necessitates corresponding peculiarities in the instruments of motion. The inquiry, however, would demand a separate consideration, as a distinct branch of natural science.

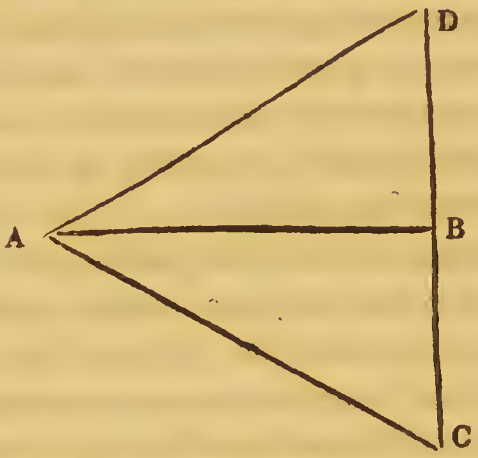
The existence of the Muscular Tissue is modified by two necessities: it is influenced in its substance by its relations with vitality; and in its form and arrangement, by the laws of mechanics. The former of these causes is wholly inscrutable. Certain vegetables perform muscular motions, without the existence of animal fibres; and the muscles of the four great classes of animals vary amongst themselves in sensible properties, to a degree that baffles every attempt at ascertaining the essential conditions of muscular contractility. The sensible differences of fish and flesh are not referable to any known variations in their vitality, or motive powers; further than that the muscular energy of the land animals is more intense, and less readily susceptible of exhaustion, than that of the fish tribes.

With respect to the arrangement of muscles, they are governed by laws purely mechanical. Wherever a great exertion of muscular force is necessary, the moving fibres are inserted in a tough inelastic cord of fibrous structure, called a tendon; by which means a considerably greater number of moving fibres can act upon a given point, than if they were in immediate contact with the bone. The tendinous tissue assumes, in different parts, a considerable variety of forms; sometimes resembling a rope, more frequently assuming an expanded surface; according to the physical necessities of the organ.

The fibres of muscles are rarely inserted in the direction of the motion they are required to produce; but form, with it, an angle, more or less considerable: by this means they carry the moveable point through a given space, with a much smaller degree of contraction. In pulling, for instance, the point A to the point B—



the muscle A B must lose its whole length, which is an evident impossibility; but



if the same effect be induced by the muscles A C, A D, they would still retain the length C B, C D, respectively, at the time of their greatest contraction.*

The muscles are frequently inclosed in tendinous sheaths, called *aponeuroses;* not for the purpose of conferring strength on them; for the muscular fibres are stronger than either the tendinous or bony tissues, and upon great and sudden exertions, are capable of breaking these organs before they lacerate themselves by their contractions. The office of the aponeuroses is

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[*] See Barclay on Muscular Motion.

to bind down the muscular fibres, to prevent them from starting out of the line of direction during their contraction, and to afford a *point d'appui* for the performance of their functions.

Animal movements are seldom performed by a single muscle; but are intrusted to the combined action of several. For in the various changes of position, which the limbs make with respect to each other, in the different stages of a given motion, a single muscle may gain or lose considerably in mechanical advantage; which would operate to produce an unsteady motion in the limbs. In general, therefore, as one muscle loses this advantage, another, operating upon the same point, gains proportionably, in each change of position; and thus the strain upon the moving point is, at all times, preserved equal.

A sudden and jerking movement of the limbs is still further prevented, by the simultaneous action of antagonist muscles, or of those which pull in contrary directions; for the one set of muscles relaxing only in proportion as the others contract, a sudden motion is much less likely to ensue.

The philosophy of muscular movements, of which a general notion may be obtained from these few instances, is like that of the osseous structure, the subject of an independent investigation. It is sufficient for the present purpose to observe, that in all these details the laws of mechanics prevail, and that the vital energy of the muscles influences their forms and arrangements only, where some other end than mechanical convenience is to be gained.

The relation of the nervous and muscular systems is purely vital, and consequently involved in the darkest obscurity. If the contractility of the muscles be excited by the transmission of electricity through the nerves, the circumstances are still unknown which determine the electric discharge. It seems now very decisively proved, that the muscles possess in themselves the principle of their motions; and that the nerves stand to them merely in the relation of excitors. The nature of the influence which the involuntary muscles receive from the nervous system is perfectly incomprehensible. Their nerves are chiefly derived from the sympathetic plexus, and are perfectly independent of volition.

To follow the minute details of circumstance, which necessitate the form and structure of the different instruments of motion, or determine the existence of different weapons of attack and defence, would be an endless, and not always a very safe task. Our views of nature are too imperfect to warrant too close an inference of cause and effect, in every case. It is sufficient to shew, that in the aggregate, the pressure of an incontrolable necessity assigns to each species its determinate combination of organs, and its definite sphere of actions There yet remains, however, one source of peculiarity, which has not been touched; and which arises out of the peculiarities of the generative functions.

Of all the organic functions, these are the most thoroughly wrapt in darkness, and impenetrability: they appear, at first sight, to bear some remote analogy to the assimilating functions, inasmuch as the one creates tissue, and the other organs; but the resemblance is too distant, to lead to any accurate conclusions. In the earliest examinable state of new-formed animals, the several organs are already in existence; it cannot therefore be determined by observation whether the individual is modelled *de toutes pieces*, or merely developed by the parent.

The simplest animals may be multiplied by division; but their natural mode of increase, is by the appearance of a new individual on some part of their surface, which remains attached, and a constituent part of the parent, till it has obtained considerable developement; when it is cast off, and assumes an independent existence. This mode of increase is technically termed *gemmiparous*.

In the higher species, the power of increase is confined to a definite organ; in some, it requires the concurrence of two organs, which in a few instances are united in the same individual, but more frequently exist in separate animals, which thus acquire the distinction of sex. The hermaphrodite species are, in some instances, sufficient to themselves for the purpose of increase; in others they require a mutual fecundation. In a very few species,* fecundation is only necessary once in a given succession of generations; in some also the same act suffices only for a certain number of successive productions; but in general each individual is the consequence of a specific fecundation.

Another important division of the subject results from the state in which the embryo is separated from the parent; which originates the distinction of *viviparous* and *oviparous* reproduction.

The causes of these differences are wholly unknown; nor has any light been hitherto thrown on the influence of either of the sexes, in producing the new animal. It would be easy to collect a vast body of conjectures and theories, and to make a proportionate shew of erudition on this obscure subject; but the positive information would still be nothing; and the humiliation of the task would be as painful to the compiler, as its extent would be burdensome to the reader.

The influence of the various conditions, arising out of these several modes of reproduction on the organization and faculties of individuals, is extensive and curious. The existence of the breasts is connected with viviparous birth; for though there are some few individuals, which appear to produce their young alive, whose offsprings are capable of seeking their own subsistence from the hour of their nativity, yet they are in reality oviparous; the young being produced from an egg, which breaks before it quits the body of the parent.

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* The aphides or plant lice are placed in this predicament.

In the several tribes of insects which are oviparous, there exist various instruments, adapted to depositing the eggs in such situations, as will afford the young proper food at the period of their bursting the shell; the whole process of making honey and wax, together with the curious propensities connected with that organization in the bee, are subservient to this necessity.

Some species of insects appear to change their element, and to acquire wings, merely for the purpose of reproduction; and the luminous secretion of the female glow-worm, is a supplement to the defect of wings in its organization, to obviate the impossibility of seeking the male in the regions of the air.

The influence of the generative organs upon the general economy is marked in the several sexual distinctions, which an attentive examination will discover even in the lowest viviparous quadrupeds, and indeed in most other species. The faculties of the mind, the dispositions, appetites, and habits, change with alterations in the mechanism and vitality of these important parts. It cannot therefore excite surprise, that they modify to a great extent the general conditions of the animal structure, and contribute largely in determining the combinations of the relative organs.

There exists one remarkable peculiarity in the generative organs of the whole organized world, which requires particular notice; namely, that the intensity of their functions is not co-ordinate with the means which nature affords for the support of individuals. The roe of the herring and of the cod is so prolific, that their multiplication would overstock the immensity of the ocean, if the individuals were not cut off as fast as they are formed. The increase of vegetable embryoes is yet more rapid.

The operation of this law is essentially requisite to meet the double necessity for insuring the continuance of species, and for affording a sufficient supply of organized subsistence for the maintenance of the different races. Eat and be eaten is the common law of organic being. From this law, man, by the power derived through his intellect, has partially escaped; but in withdrawing himself from the attacks of the inferior animals, his rapid increase has subjected him to those of his own species. The human race multiplies faster than is compatible with the well-being of the individuals; hence poverty and crime *within the pale of society*, and warfare *between nations*, become the necessary instruments for re-establishing the balance. This is a melancholy fact, but it is fact. It is absurd to imagine that man alone is uninfluenced by this otherwise universal law of organization ; and Mr. Malthus would perhaps have avoided much calumny and considerable trouble, if he had taken the general instead of the individual proposition, as the basis of his elaborate and philosophic system.

From the sum total of external causes, the character and identity of each species is fixed by an immutable necessity. If the conditions change, the organization must alter, or the species perish. The number therefore of possible organizations is limited. The plumage of the bird united to the gills of the fish, would form a being embarrassed in function, and incapable of continued existence. A perfect acquaintance with this law enables the anatomist to judge, from very slight traces, concerning the habits, character, and general conformation of an animal. A powerful canine tooth necessarily implies a carnivorous arrangement of the intestinal canal, strong jaws, dense muscles, bulky nerves, a lank flexible body, toed feet, and bloody and ferocious habits. Thus a single bone gives general indications of an entire skeleton ; from which may be deduced the nature of its actions, the nerves and muscles, requisite to put it in motion, and the senses and appetites necessary to give motives for its volition.

The combinations which poetic imaginations have invented, hippogryphs, centaurs, flying men, hydras, and 'chimeras dire,' could not therefore subsist *in rerum natura.*

Nature, it is true, sometimes produces incompatible combinations, usually termed monstrous births. These, however, necessarily perish, and the permanent distinction of species continues uninterrupted.*

The number of organized beings is likewise influenced by their balance among each other. For as agriculture banishes many vegetables, considered as weeds, so the multiplication of man has expelled certain species of animals from his presence. It is by no means improbable that the same law may have operated among inferior animals, and diminished the sum total of organic forms. In these kingdoms the brown rat has totally annihilated the black species, and probably will do the same wherever it appears. The extinction, not only of species but of genera, is a fact now proved beyond the possibility of contradiction, by the evidence of their remains preserved within the bowels of the earth.

Whether new combinations occasionally spring up by hybrid production, or by the varieties impressed by physical circumstances becoming permanent, is a subject of curious enquiry.

The views which these pages unfold seem to set at rest a question long agitated concerning the plurality of inhabited worlds; by demonstrating that the animal and vegetable races, which exist in our planet, must be peculiar to it. Each individual has its particular organization, in virtue of the physical circumstances in which it is placed; and a greater or less degree of propinquity to the sun would be sufficient to alter the least of these conditions. The chemical constitution of this planet cannot exactly resemble that of another: their organized productions cannot therefore be the same. It is not indeed less repugnant to received notions of the Great First Cause, than to our knowledge of facts, to suppose that the innumerable heavenly bodies, which roll in the immensity of space, are mere repetitions of each other; that the globe we inhabit is an epitome of the universe; and that it contains within its narrow limits examples of the sum total of created things.*

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* Lawrence, in Medical and Chirurgical Transactions.

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* "Le soleil faisant éclore, par l'action bienfaisant de sa lumière et de sa chaleur, les animaux et les plantes, qui couvrent la terre, nous jugeons par analogie, qu'il produit des effets semblables sur les autres planètes. Car il n'est pas naturel de penser, que la matière, dont nous voyons l'activité se développer en tant de façons, soit sterile sur une aussi grosse planète, que Jupiter, qui, comme le globe terrestre, a ses jours, ses nuits, et ses années; et sur lequel les observations indiquent des changemens, qui supposent des forces très actives. Cependant ce seroit donner trop d'extension à l'analogie, d'en conclure la similitude des habitans des planètes aux habitans de la terre. L'homme, fait pour la température dont il jouit, et pour l'élément qu'il respire, ne pourroit pas, selon toute apparence, vivre sur les autres planètes. Mais ne doit-il pas y

avoir une infinité des organisations, relatives aux diverses constitutions des globes de cet univers? Si la seule difference des élémens et des climats met tant de variété dans les productions errestres, combien plus doivent differer celles des diverses planètes et de leurs satellites? L'imagination la plus active ne peut s'en former aucune idée; mais leur existence est très vraisemblable."

La Place, Essai sur les Probabilités.

CHAPTER IV.

OF THE LAWS OF

VITAL ACTION.

BOUNDS of the enquiry—SENSATION AND REACTION—Their several varieties—Comparison of the moving forces in nature—Conditions of vital action, presence of nutritive fluid, duration of stimulus—Permanence of reaction after the stimulus is removed—Relations of quantity in stimuli—Excessive stimulus—Accumulated and deficient sensibility—The ratio recipientis—Theory of catarrh—Deficient stimulus—Appetites—St. Vitus's dance.—HABIT—Its influence on the sentient fibre, on the nutritive functions, on the contracting fibres; on perception, and judgment—Alternation of stimulus—Ocular Spectra—Theory of agreeable colouring—Regulated repetition of stimuli.—SYMPATHY—INSTINCT—Explanation of some apparent cases of sympathy—Ghosts—Sympathy between individuals—Mesmerism.—ASSOCIATION—Local and diffusible stimuli—ORGASM—Chilliness after dinner—Resistance to pain—Bion's critique on a line of Homer—Rending garments, in grief—Brunonian practice of physic.—INTOXICATION—Tonic stimuli—PHENOMENA OF CONTRACTION—Fatigue, spasm, nutritive contraction—SLEEP—not a function—Partial sleep—Dreams—SOMNAMBULISM—Nocturnal animals.—DELIRIUM—Influence of temperature on sleep.—HYBERNATION—Sleep of plants—Affections of the nutritive functions during sleep.

CHAPTER IV.

OF THE LAWS OF

VITAL ACTION.

"Les vrais ressorts de notre organisation ne sont pas ces muscles, ces veines, ces artères, ces nerfs, que l'on décrit avec tant d'exactitude et de soin. Il réside, comme nous l'avons dit, des forces interieures, dans les corps organisés, qui ne suivent point de tout les lois de la mécanique grossière, que nous avons imaginée, et à la quelle nous voudrions tout réduire."

Bouffon, tome ii. p. 485.

THE preceding pages have been dedicated to an examination of the law which governs the form and existence of the different living combinations; and to an hasty and general review of the mechanism of organization. The connection between the structure and functions of every species, and the elementary constitution of its substance, has been exhibited; and its characteristic peculiarities have been shewn to result from a necessity, which determines the highest faculties of intellect, no less than the simplest impulsions of vegetable nutrition; and operates as despotically, in producing a Cæsar, or a Newton, as in originating a Polype or a Tremella.*

In these facts are discovered a connection between the inorganic and organized kingdoms of nature; which should lead to an anticipated conclusion, that both these classes of bodies derive their existence from the same sources. The connecting link has hitherto indeed escaped enquiry; but the inference so commonly drawn, that the phenomena of life belong to an order distinct from that of inanimate existences, is too hasty a deduction from this ignorance. Every analogy, on the contrary, favours the opposite belief that all things subsist in mutual dependence, obedient to one common and universal law.

In the present condition of physiological knowledge, however, the phenomena of organized existence must be considered as insulated from the rest of nature; and the most general facts must be referred to unknown forces, resident in the several tissues. The existence of these forces, while their real nature remains unknown, must be taken as an ultimate fact. The formation of vague and uncertain theories for their explanation has contributed nothing towards the advancement of knowledge; and philosophy more usefully directs its researches to ascertain the laws under which vitality manifests itself, in the several tissues, and in the different species.

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* Φύσις κεράτα ταυροῖς
Ὅπλας δ' ἔδωκεν ἵπποις
* * * *
Τοῖς ἄνδρασιν φρόνημα.

The *nisus* towards dissolution, it has been already stated, is not the same in all organic combinations. In some forms the influence of chemical affinity is more efficient than in others, and in these the developement of vital power is proportionately less necessary to their formation and preservation. The living forces therefore exhibit themselves under a vast variety of modifications, in the several organized tissues, concerning which some useful distinctions may be established.

All the phenomena of life may, in ultimate analysis, be reduced to two simple facts: a *sensation* of the presence of foreign bodies, when brought into contact with the organized tissue; and a *reaction*, by which the tissue, and, in some cases, the foreign body also, undergoes a consequent alteration.

The term *sensation*, it should be premised, is employed by physiologists in a peculiar sense. To explain its use, it must be understood that all bodies do not act indiscriminately upon every living tissue; each particular organization being so constituted, as to stand in relation with its own peculiar series of agents, by which alone it can be congruously affected. These agents are called the *stimuli* of the organization.

The action, which results from the presence of a stimulus, being neither chemical nor mechanical, the tissues are considered as feeling or distinguishing between the different substances applied to them. Some affection of the living tissue must result from external impact, to determine its action, or quiescence: this affection, inasmuch as it depends not upon the inorganic properties of the tissue, but arises out of its vitality, requires a distinct appellation; and from analogy it has been termed a sensation.

In all tissues, unconnected with a nervous apparatus, these phenomena take place independently of consciousness; and as they occur in beings altogether divested of nerves, they cannot be considered as connected with perception. Sensibility, therefore, in this restricted use of the word, represents merely the unknown modification of the tissue, which causes it to react, or not to react, according as the substance applied is, or is not, one of its appropriate stimuli. In this there seems to be little more than an habitude of the tissue with respect to its stimuli, analogous to that, which in chemistry is termed *elective attraction*.

This analogical use of the word "sensation" is perhaps scarcely justifiable, on account of its obvious tendency to mislead the imagination. Its close etymological connection with the organs of sense, which must at every turn suggest the notion of consciousness, renders it a very unsafe term, when used to express a force, independent of perception, a force which exists in vegetables, in amputated portions of animals, in eggs, and in seeds.

But it is rarely within the power of language to convey ideas with perfect precision.* Not only the corruption of speech, but the very progress of knowledge tends to unsettle the application of words. New ideas, as they arise, become insensibly connected with old expressions, whose meaning is consequently extended, varied, and often entirely changed.† To invent new terms upon every accession of ideas is impossible. For as that which is new can only be conceived by its analogies and relations with facts already known, an isolated and unconnected technicality, introduced into language, will rarely serve the purpose of its inventor. It is for this reason that mankind have uniformly had recourse to sensible images, and to known combinations, as the sources from which they have enlarged their vocabulary; and they have preferred the adaptation of old terms to new significations, whenever it could be readily effected; as the easiest method of suggesting their own ideas to general comprehension. In the present instance, popular language has too firm possession of the term "sensation," to prevent a certain degree of confusion in its technical application; but in order, as far as possible, to avoid confusion, *perception* and *perceptibility* will be employed in the following pages, wherever the *sensibility of relation* is opposed to that low variety of sensibility above described, which presides exclusively over the nutritive functions.

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* "Ce n'est point aux philosophes, c'est au besoin qu'on doit l'invention des langues."—*Helvetius.*

† Thus *virtus* which etymologically signifies *manhood,* with moralists implies the obligations of man in society; with theologians it designates an *unmanly* abnegation of the right of judgment; and among the Italians its derivative *virtuoso* signifies —the very opposite of man. Sometimes terms pass by a curious mental operation into their directly contrary meanings; as when "*presently*" is used for the time not present, and "*probably,*" for that which cannot be proven.

Relative sensibility is that modification of living power, which is attended by consciousness; and appears to have its exclusive seat in a nervous apparatus. It ought, perhaps, on this account, rather to be considered as a function than as a primitive force.* But the distinctions between tissue and organ, vital property and function, are too arbitrary to admit of an universal and rigid application; and utility alone must decide upon their individual appropriations.

To express the reaction, which takes place in the living tissues, upon the application of their appropriate stimuli, physiologists have adopted the term *contraction*; in this, as in the preceding case, deriving their notions from the more obvious movements, which occur in animal tissues of the highest order.

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* Magendie Précis de Physiologie.

The precise nature of the simplest mode of organized reaction, which constitutes *nutritive*, *automatic*, or *organic* function, is perfectly unknown. It takes place in portions of the living solids, too minute to be submitted to the test of ocular observation. A particle of blood may be traced in its course through a vessel; it may be seen entering a gland, from which it escapes totally altered in its constitution, under the form of a given secretion; but the nature of the process which it has undergone escapes the scrutiny of the senses, and is wrapped in the most impenetrable obscurity.* In like manner the food may be traced through every stage of the digestive process, and its progressive alterations noted; but the peculiar action of the living alimentary tube is not rendered in the least manifest by the observation. It is from analogy alone, with the sensible contractions, which take place in the fibres of muscles, that these various imperceptible movements are designated by the term contraction.

Bichat, the original author of this mode of considering vitality, recognizes three varieties of organic reaction. The first, which he calls *organic insensible contraction*, but which is better designated by the terms automatic or nutritive contraction,* includes all the minute vascular actions of assimilation and absorption, which being independent of volition, are conducted by causes inherent in the organs themselves.

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* The passage of an electric shock, as has already been observed, is insufficient to explain the differences of secretion.

His second variety he terms *organic sensible contraction*, which embraces those manifest muscular movements, that take place in organs exempt from the influence of volition, such as the heart, and muscular coat of the intestines.

The last variety he has named *animal contraction*, including by the term, all those muscular movements, which are directed by the will. This arrangement, however, is evidently inadmissible; in as much as it is founded upon a distinction extrinsic to the subject. Both the last modes of contraction are perfectly alike, and are included by Haller under the appellation of *irritability*. The circumstance of a muscle being connected, or not connected, with the nervous apparatus, and thereby being subservient or independent of volition, is utterly foreign to its structure *as a muscle;* and if the nervous communication between the brain and an organ of animal contractility be cut off, its muscular properties still remain entire and unaltered.

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* The use of the term '*organic*,' as opposed to *animal* action, is vicious; in as much as all living actions are organic. It involves likewise the odious cacophony of organic organs.

There are, it is true, some slight differences between the mechanical arrangement of the fibres of those muscles, by which organic movements are executed, and those which obey the influence of the will, which it is necessary for the physiologist to bear in mind; and for this purpose Bichat's discrimination is not without its convenience: but it must always be remembered, that the two forces are so much alike, in all the different cases, that there are but slight philosophical grounds for establishing a separation of their phenomena, into separate and contrasted orders.

The several distinctions here attempted both between the modes of contraction and of sensation should indeed be regarded, as in a great measure artificial; their value depending rather upon their utility in the processes of generalization, than upon their close approximation towards philosophical accuracy.

Every distinct tissue possesses its own specific vitality; and the differences of sensibility, which give birth to a flower or a muscle, must far exceed those, which make the distinction between automatic and animal function. That the varieties of sensibility, established by Bichat, consist rather in degree, than in kind, seems evident likewise from the sudden developement of the perceptive sensibility during the inflammation of organs, divested of this faculty, in their healthy condition.* In like manner, the transition from the insensible contractions of nutritive function to the visible action of voluntary muscles, takes place, by such fine shades, as have involved physiologists in endless disputes concerning the muscularity or non-muscularity of particular organs.

In tracing the phenomena of nature, from the highest and most complicated movements of volition, down to the simple gravitation of matter towards a common centre, it is difficult to perceive the points, at which the influence of one modification of force ceases, and another commences.

There is every reason, short of positive proof, for supposing all the phenomena of life to depend upon one common principle, variously developed in the different living tissues: between the lowest exertions of this principle, and the cases of mere chemical affinity, the differences are scarcely appreciable; and the resemblance between chemical affinity and the attractive force of masses is still more striking.

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* A peculiar instance of this fact may be adduced, in the very painful stitch, which accompanies inflammation of the lungs. The seat of this affection is the membrane lining the chest, a membrane which, in health, is not capable of propagating sensations to the cerebral centre. Bones and ligaments which are insensible to the rudest shocks during health, are most tenderly susceptible when in a state of disease.

So strictly similar is the mode of operation of all these different forces, that language affords but one common term for the sympathetic solicitations of love and friendship, and the mutual action of unorganized bodies. It is on this account that the mystic philosophers of antiquity attributed all things to the divine Eros;* and that Lucretius commences his system of nature by an invocation to Venus.

It must however, be repeated, that the hypothesis arising out of this view, (beautifully grand as by its extreme simplicity it is,) belongs in the present state of our knowledge, rather to the province of poetry, than of physiology.

The sensibility and contractility of organized tissues, not being inherent in their ultimate particles, are developed by the functional actions, which take place between the solids and fluids; and the suspension of these actions is speedily followed by death.† If the supply of blood be cut off from a limb, by means of ligatures made

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Ἤτοι μὲν πρώτιστα χάος γένετ' αὐτὰρ ἔπειτα
Γαῖ' * * * * * * * *
* * * * * * * * * *

Ἠ δ' Ἔρος ὅς κάλλιστος ἐν ἀθανάτοισι θεοῖσι
Λυσιμελὴς πάντων τε θεῶν πάντων τ' ἀνθρώπων
Δάμναται ἐν στήθεσσι νόον καὶ ἐπίφρονα βουλήν.
Hesiod. Theogonia.

† This indeed follows from the very meaning of the term, life is essentially action.

upon its arteries, sensibility of all kinds is in a very short time extinguished ; and the part dies, and undergoes the same changes, as supervene, on the death of the whole body. It is upon this principle, that tumours and other excrescences are removed, by inclosing them within the ligature of a silken thread, or even of an hair ; an operation frequently employed in the practice of surgery.

The influence of the circulation upon the sensibility of relation, is still more immediate. If the blood by any means be prevented from flowing in its accustomed quantity towards the head, the perceptive functions are instantly suspended ; the animal faints, and unless the cause be speedily removed, syncope is exchanged for death*. If, on the other hand, the circulation continue uninterrupted, and the ligature be cast round the nerves of a limb, so as to cut off its communication with the cerebral centre, the other tissues will continue their functions, uninterrupted by the accident. An injury having been inflicted upon the nervous apparatus, the communication of sensations to the brain, and of volition to the muscles, will indeed of necessity be suspended ; but the limb will continue to live, and its muscles to contract in obedience to other stimuli : as if no such operation had been performed. These counter-experiments clearly demonstrate that the nervous system is not the fountain of life to the rest of the economy; but receives its animation, in common with all other tissues, from the action between its own vessels, and the circulating fluids.

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* This is the theory of the fainting, which so frequently occurs during the process of letting blood.

The manner in which the blood is distributed to the different organs is in strict agreement with this conclusion; the quantity, which flows to any one of them, being closely commensurate with the intensity of its functions. One sixth of the whole circulating fluids has been calculated to pass through the brain, in the human subject; and the muscles, which are the parts most liberally supplied with nerves, have likewise the largest quantity of blood-vessels in their structure.

Vitality being thus at once the offspring and cause of function, there is exhibited a circle of actions, which affords neither commencement nor termination; and in which the primary cause is hidden from contemplation. The renewal of the vital energy is however in some way connected with the function of respiration. The blood of the mammalia, in vivifying the solids, undergoes that unknown change, which, while it confers upon it its purple colour, renders it unfit for the repetition of its functions. A counteracting process takes place in the lungs, and the energizing property of the blood is restored. The chemico-vital action of the air in these organs is therefore demonstrably the source of regenerated vitality.

To the universality of this law there exists but one exception; and that perhaps but an apparent one. The blood, which circulates in the arterial system of the fœtus, is not distinguishable by its colour from that which flows through the veins; it is therefore presumed to be uninfluenced by the action of oxygen. But the old theory, that this element is received from the maternal arteries, is entitled to considerable weight. The circulation through the placenta, or organ of communication between parent and child, is momentarily necessary to the fœtal life; while its suspension takes place with impunity, as soon as the infant has access to the external atmosphere. The inference that the functions of the placenta and lungs are mutually vicarious cannot be mistaken.

In order that a stimulus should produce its effect upon a living tissue, it is requisite that they remain for some definite time in contact. Flashes of lightning frequently pass across the field of vision unnoticed, owing to their extreme rapidity; and bullets, from the same cause, will sometimes penetrate the body, without exciting much sensation.

The period necessary to the production of stimulation is not the same with respect to all stimuli, or to every tissue: in some instances it is very considerable. Advantage is taken of this law, in cases of poisoning, to administer emetic drugs, which excite the inverted action of the stomach and evacuate its contents, before the poison has time to act upon its tissues, and to generate disease. Blisters do not irritate the skin, till they have been applied some hours; febrile contagion lies dormant for many days; and the poisonous saliva of hydrophobic animals does not excite its peculiar disease until the lapse of a period of various and uncertain duration. The rapidity, with which action follows the application of stimuli, varies as the intensity of the stimulating cause, and of the living energies of the tissues, to which they are applied.

When, on the other hand, a stimulus has once made its impression, the consequent action continues for a certain time after the cause is removed. The first effort of vomiting generally expels the whole of an emetic drug; but the action is more or less frequently repeated, before the impression of the medicine is completely worn off. This law of living energy is happily illustrated by a trifling amusement, common among children. If a piece of lighted wood be fastened to a string, and whirled round with considerable velocity, the visible effect is that of a circle of fire: for the impression made upon the retina, by the flame, at any one point of its rotation, excites an action which continues till the wood has performed its revolution, and has returned to the same spot, to renew its stimulation; and thus a circle of action is formed in the retina, corresponding to that of the revolving stimulus. It is thus, that permanent effects take place in the economy from periodic causes ; and changes are induced in functional action, by the repeated administration of the same drug.

The effect, which any stimulus can produce on the living tissue varies according to the quantities, in which it may be present. In too small a dose, its effects are, with respect to function, positively null. An excessive dose may increase, suspend, or invert the action of the organ to which it is applied ; or it may produce an action of a totally new character. In the organs of sense, excessive stimulus, instead of sensation, produces pain ; in the muscles it substitutes convulsion for regulated action. In the secreting organs, it first increases, and then suspends secretion. After a time however secretion again commences, but the product is more or less extensively modified ; and in some cases the blood flows pure and unchanged, through the secretory vessels. All these phenomena may be observed in the course of a severe inflammatory cold. If the nutritive vessels be the seat of excessive stimulation, acute inflammation and fever are the usual consequences.

When an immoderate stimulus offends more by its duration or repetition than by its positive excess, the vessels of a gland so excited are apt to become paralytic ; and the secretion gradually diminishes or altogether ceases to flow. If this paralysis of the vessels extend to the nutrient system of the organ, the part wastes and shrinks in its dimensions. Sometimes, however, the nutrient vessels increase in energy, from an alteration in the balance of forces, occasioned by the suspension of secretion; and then the organ becomes enlarged, and at the same time condensed in substance. Both these conditions are daily exhibited in the livers of such persons as indulge in the habitual abuse of spirituous potations.

The application of even an healthy stimulus, or of one not greatly exceeding that which calls an organ into regular function, produces a certain exhaustion of living power. This, in its turn, is followed by a more or less extensive diminution of function, during which vital power is again accumulated. Although, therefore, every tissue has its own specific degree of living energy, that degree is not prescribed with the same rigid and undeviating accuracy, observable in the physical forces of unorganized species. A mass of brute matter, of a given size and weight, is at all times attracted to the earth with the same velocity, while passing through a given medium, and descending from a given height: and the increments of its celerity are always the same in the same successive parts of its passage. In like manner, the force of chemical affinity is ever constant; and the results of combinations, once known, may afterwards be calculated *a priori* with a perfect certainty. In organized bodies, on the contrary, there is a continued oscillation of the moving forces, within certain limits, which determines a greater or smaller reaction, upon the application of a given stimulus, according as it operates upon a tissue, whose sensibility is at the time exhausted, or accumulated above its medium intensity. The terms *excessive* and *insufficient* stimulus are not, therefore, applicable to definite quantities of a foreign substance, but to portions varying with all the different conditions of the living solids.

The range of excitement, within which the organs may be goaded, and yet return to healthy action, is not very extensive; and, that range once exceeded, they acquire new modes of action, which are neither compatible with their own existence, nor harmonize with the movements of the rest of the machine; and the consequence is the disease or perhaps the death of the individual. Upon this physical fact is founded the maxim of *ne quid nimis*. Neither the force nor the rapidity of organic movements can be indefinitely increased; and every attempt to push the pleasurable sensations, derivable from functional action, to an excess, defeats its own end, and is followed by a proportionate interval of debility, derangement, and disease.

Organized beings are not then, what they are by virtue of their present circumstances alone, but are powerfully modified by the conditions of their previous existence. The *ratio recipientis* avails much more with living than with unorganized species. This law operates incessantly in regulating the impressions made upon the living tissues by the surrounding elements.

If the hands be placed for some little time, the one in very hot, the other in very cold water, and both be then removed to water of an intermediate temperature, the impression made upon the heated hand will be a sensation of cold; while the chilled hand will feel a glow of heat from its change of situation. In this experiment the heated hand has had its vitality comparatively exhausted by the superior stimulus of the hot water, and is therefore less excited by the tepid fluid, than the cooled extremity, whose vital power has been relatively accumulated by its previous exposure to a low temperature. Persons leaving a frosty atmosphere for the shelter of a warm room, thus experience pain, a prickly tingling, and flushing of the skin, from that moderate degree of heat, which is barely comfortable to those who have not been so exposed to cold. It is in consequence of a similar accumulation of excitability resulting from the winter's inaction, that vegetation commences in the spring, at a temperature which, in the autumn, is insufficient to maintain life in the exhausted foliage.

The applications of this law are endless. The

Russians, taught simply by experience, accommodate themselves to its dictates, in their treatment of organs attacked by the severe frosts of their climate. The exposure of the body to these excessive low temperatures, so far increases their susceptibility to the peculiar stimulus of heat, that its sudden influx produces a re-action, instantly destructive of life. When, therefore, a limb has been frost-bitten, the first application which is made to it is that of a gentle friction with snow, which, being a few degrees above the temperature of the atmosphere, becomes a stimulus to the part, proportionate to its new condition, and excites in it as much action as is consonant with a return to health. The stoppage of the circulation, which extreme cold thus produces, is unattended with pain: persons are therefore liable to fall unconsciously into this state, and so to enter into heated apartments; when the frost-bitten organ has its excitability totally destroyed, gangrene ensues, and the part is irrecoverably lost.

From the foregoing circumstances, it seems probable that the catarrh, that vexatious torment of our insular climate, is the more frequent result of a sudden transition from cold to heat, than (as is usually imagined) from heat to cold. It is true that catarrhs are frequently caught by exposure to the night air, after leaving crowded assemblies; but the generally exhausted condition of the frame at that period of the day, which renders it more prone to irregular action, will explain the fact. The injury also may be attributed, in these cases, to the return from the open air to the warmth of the bed-chamber; and there is this additional reason for such a supposition, that persons walking home, and entering the house with that glow on the surface which is produced by exercise, are less likely to catch cold than those who return under the shelter of a covered carriage.

The inconveniences which spring from deficient stimulation are much less urgent than those of excessive excitement. If stimulation be less than natural, the excitability accumulates, and thus tends to adapt the organ to its new circumstances. This, however, is true only within certain limits. The absence of accustomed stimuli is the source of the animal appetites. Hunger is an uneasy sensation, in some measure connected with the accumulated sensibility of the stomach; and the amorous rage of animals, unperverted by reason, has its sole origin in a similar cause. Deficient mental excitement produces the disease which the French denominate *ennui*. The accumulated sensibility is testified by that restless propensity to motion, which in vulgar language is termed "fidgets," "beating the tattoo," &c. The movements thus produced are efforts to expend that vitality which few know how to employ, of whose scantiness all complain, and which, often possessed without enjoyment, is never relinquished without regret.* Connected with these involuntary movements are those convulsions which constitute the disease called St. Vitus's dance; a malady peculiar to the abundant excitability of youth; and in many instances, perhaps, occasioned by the forced confinement of schools and drawing-rooms.

Amidst the endless variations of circumstances resulting from climate, and the wants and passions of the individual, it would be impossible to preserve the balance between excitability and stimulus, if some other principle were not called into action, to obviate the ill effects of inevitable excesses. Such a principle is habit, or that law of the economy which renders the effects of given stimuli less violent, in proportion as they are more frequently applied. The influence of habit seems to fall most especially upon such impressions as excite pleasurable or painful emotion; and upon such as are made upon the skin and mucous membranes. When a stimulus continues for any length of time upon these tissues, its effects gradually diminish, till at length it becomes quite inert. Sapid substances, held for a continuance in the mouth, cease to excite their appropriate taste. So, also, rings and other ligatures at first occasion a sensible uneasiness in the seats of their pressure; but, after a short time, cease to be perceived. It is, therefore, a customary mode of refreshing the memory, to put the ring upon another finger than that on which it is usually worn, in order that the irritation it occasions in its new situation, becoming associated with the fact to be remembered, may recall it, from time to time, to the wearer's recollection.

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* *Ennui* is a derivative from some obsolete verb, whose root is the substantive "*nuit.*" There is not any error more common than that of mistaking the lassitude of indolence and apathy for fatigue; and of supposing the faculties to be exhausted, when they are merely benumbed for want of motives.

As the continued application of a stimulus obliterates the sensibility of the tissue, with regard to that substance, so its frequent application diminishes the intensity of effect produced by its presence. The physical and moral results of this law are numerous beyond the power of detail. The habitual abuse of intoxicating liquors is familiarly known to diminish their impression on the intellect. The unpractised debauchee is overcome by a few glasses; while the confirmed sot can swallow as many bottles, without losing his small remaining portion of reason.

This position is likewise true with respect to opium and the other diffusible stimuli. Some persons habitually take quantities of these drugs, which would at once extinguish life, if swallowed for the first time. Physicians are constantly compelled to increase the quantity of medicines, or to change them for others of similar efficacy, in order to obviate this tendency in the economy, when they wish to preserve a continued action in the system.*

The influence of habit, in regulating the impressions of the elements, is abundantly notorious. A peasant, who lives habitually exposed to the seasons, is much less affected by their changes, than the delicate citizen, to whom sudden and violent alternations of temperature are less familiar. The secret of the oriental jugglers, who, in their late exhibitions in this country, passed swords into their stomach, consists in blunting the painful impressions these bodies at first excite, by a continually repeated application of their surface to the lining membranes of the œsophagus.

The great art of life consists in obviating this apathizing influence of habit, and in so economizing the pleasurable sensations, as that something may remain to be enjoyed when age advances. The indifference which use occasions, even respecting the keenest sensations, is the enemy against which humanity is incessantly struggling. The pleasures of the table, of literature, and of the arts, even the agitating vicissitudes of gaming, lose their charm by reiteration. Men who meet eagerly part with carelessness: even worth cannot always fix the affections of the friend, nor beauty chain the inconstancy of the lover. The greatest advantage, perhaps, of wealth, lies in the facility it affords of changing the train of our sensations, and of awakening interest, by a frequent variation of pursuit, of company, and of residence.

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* One individual, within the author's observation, was in the constant habit of taking two liqueur glasses of laudanum in the course of the day. The quantity of opium usually consumed by individuals in Turkey would be fatal in constitutions unhabituated to its stimulus. This influence of habit, however, is merely temporary, the sensibility of the tissues rapidly reviving after a short abstinence. Hence, in the employment of cicuta, digitalis, and other narcotic drugs, when their use has been for a short time intermitted, it is necessary to re-commence with the smallest doses, and not with those in which they were last taken.

The superior susceptibility of the relative organs to the benumbing influence of habit, has led Bichat to doubt of its operation on the nutritive functions. Its power, however, is rendered very conspicuous in the gradual slackening which takes place in all the automatic movements, in the progress of life. Function is discharged with the greatest rapidity in the earliest periods of existence; and it insensibly abates till the moment of its final cessation.* Many morbid symptoms, in like manner, disappear, after a short time, through the influence of habit, notwithstanding the continued presence of their cause. The circumstance, also, of certain eruptive diseases attacking the same subject but once is clearly referable to the system's being accustomed to the stimulus of the contagious miasma. Thus, likewise, the inhabitants of marshy districts become steeled against the deleterious influence of their exhalations; and are less easily affected with ague than strangers, who occasionally visit them; and (to conclude; for the abundance of instances is overwhelming), foreign substances, bullets, &c., when buried in the flesh, though at first they excite violent inflammation, in the end cease to produce uneasiness.

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* The arterial pulse of infants beats more than 120 times in a minute; in extreme age it seldom exceeds 65.

This operation of habit upon the sensibility, curiously contrasts with its influence upon contractility. Whenever an organ or tissue has been thrown into a given mode of contraction, it becomes disposed, at each repetition of the stimulus, to repeat the action with greater vigour, facility, and steadiness. The food to which the stomach is habituated, is most easily digested. The accustomed burden is the most easily borne: and if a chairman and a porter should exchange their functions, they would both lose in force and in agility, in their new situations.

This difference in the effects of habit is strongly marked in its influence upon the perception and on the judgment. By the repeated examination of a subject, those movements of the sensorium, in which the ideas essentially consist, are strengthened and rendered more accurate, and they are more easily recalled, and combined in every possible variety. Habit, therefore, increases the accuracy of comparative notions, at the same time that it blunts the sensitive impressions of pleasure and pain, by which they were originally excited. This is the physical ground of Fontenelle's beautiful remark, that "Les plasirs ne sont point assez solides pour souffrir, qu'on les approfondisse. Il ne faut que les effleurir. Ils resemblent à ces terres marécageuses sur lesquelles on est obligé de courir légèrement, sans y arrêter jamais le pied."* It is in this way that the pursuit of knowledge so frequently operates unfavourably to happiness.

> Still flying from Nature to study her laws,
> And dulling delight by exploring its cause,
> *We* forget how superior for mortals below
> Is the fiction they dream to the truth that they know.†

The combined operation of habit, in destroying the vivacity of impressions, and in strengthening the accustomary modes of action, while it renders mankind discontented with present circumstances, fetters them to the oar, and often prevents even the effort to escape. Habitual modes of thinking and of acting, gain a preference over salutary innovations; prejudices become confirmed by time, and precedent usurps the seat of reason. The sense of established injustice, in the meanwhile, is enfeebled, and the chain, by long wearing, ceases to gall. The most disastrous administrations of government thus find their conscientious supporters, and the most debasing superstitions their confiding martyrs. That which is not approved, is tolerated; that which has long subsisted, appears natural and inevitable; and ages pass away without witnessing any material advances in society towards wisdom or happiness.

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* Dialogues des Morts—"Celui," says Chamfort, "qui veut trop faire dépendre son bonheur de sa raison, qui le soumet à l'examen, qui chicane, pour ainsi dire, ses jouissances, et n'admet que les plaisirs délicats, finit par n'en plus avoir. C'est un homme, qui à force de carder son matelas, le voit diminuer, et finit par coucher sur la dure."

† Moore.

When an organ has been exhausted by the frequent repetition of one stimulus, its sensibility may still be excited by the application of a second. Tea, coffee, wine, spirits, æther, and opium, taken in succession, produce more permanent effects, than if any one of them were separately and perseveringly employed. To this law may be referred the very singular phenomena of ocular spectra, described in Dr. Darwin's Zoonomia. If the eye be steadily fixed, for any length of time, upon one of the primitive colours, so as to become fatigued by its contemplation, and then be suddenly removed to some compound colour, of which the first is a constituent, this second colour will not excite the same idea in the mind, which it usually does; but that which the combination should raise, if the primitive colour, first contemplated, were altogether absent from the combination. Let a red wafer, for example, be fastened in the centre of a sheet of white paper, and placed in a strong light. If the eye be steadily fixed upon it, so that the rays proceeding from it shall impinge continually upon the same points in the retina; and if, when the effort begins to create a sense of fatigue and of pain, the eye be then removed to another part of the paper, a bright green spot will be seen, in size and shape resembling the wafer. Of this curious experiment the explanation is simple. White is a sensation produced by a due mixture of red, blue, and yellow (abstraction being made of the intermediate tints); and green results from a combination of blue and yellow. A pencil of white light would, therefore, appear green, if all its red rays were removed. But that portion of the optic nerve, which has been fatigued by the contemplation of the wafer, being no longer stimulated by the red rays, it is affected in the same way, as if they were absent from the combination. The impression, therefore, made upon the mind is that of a green circle, corresponding with the circle of exhausted tissue in the optic nerve.

This law of vital action is of frequent application. It explains the refreshment derived from a change of pursuit, when the mind has become fatigued by assiduous application;* and the prolongation of appetite, which results from the alternation of sweets and acids, high seasoned and simple viands. By this property of the sentient tissue may also be explained many of the facts respecting colours; as well those employed in pictures, as for ornamental purposes. The primitive colours are in general discarded from the decorations of houses and of dress, because the intensity of the sensations they excite is fatiguing, and creates disgust. The middle tints, composed of many colours in primary and secondary combination, are less brilliant, and refresh the eye by their blended impressions. Gaudy colouring in pictures is displeasing, because it is unnatural; but it is admired in theatrical exhibitions and in processions, because spectacles are sought for the purpose of procuring vivid sensations; and because the rapid succession of objects in these amusements prevents fatigue. Where contrast is demanded in the assortment of colours, the several complements of white afford the happiest mixtures; such as scarlet and blue, red and green: but where harmony and unity of effect are required, those colours should be chosen which contain nearly the same primitive tints; for which reason ternary compounds are preferable to binary colours, as affording closer approximations of hue.

If a stimulus, not too great, be regularly repeated, at such intervals as permit the sensibility to recover the effects of the last dose, its action upon the system, instead of diminishing, will increase. Dr. Darwin explains this extraordinary fact by the combined force of irritation and of association. The position seems, however, to be principally applicable to those stimuli, which are employed for restoring healthy action, when the constitution is debilitated ; and in this case, the periodical administration of drugs may add to their efficacy by conspiring with those naturally periodic actions, which have been disturbed by the disease, and which it is the business of the physician to restore.

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* Menage has worked this fact into a maxim—

Πόνου μεταβόλη ἐίδος ἐστ' άμπαυσέως.

The several organs of the higher classes of animated beings are so bound in mutual connection, that it is scarcely possible for one of them to be violently affected without a consequent modification of all the others ; and few, even of the slighter impressions, are exclusively confined to the organs in which they originate.

There exists, however, a more peculiar influence, which is exerted between remote organs, and by which the one is thrown into action, in consequence of particular impulses, impressed upon the other. This influence has received the appellation of *sympathy*, a term merely expressive of the *fact ;* but, like other similar terms, too frequently taken as representing the *cause* of that fact.

The nature of sympathy is wholly unknown; and the circumstances under which it operates are but imperfectly understood.* It is observed to take place between parts very differently connected. One cause of sympathetic action seems to be *continuity of surface.* Thus inflammation is rarely confined to one spot in a membrane, but diffuses itself over the whole. So also certain medicines, taken into the stomach, influence simultaneously the entire alimentary canal.

Sympathy likewise subsists between the *different component tissues of the same organ;* as when inflammation of the pleura excites a sympathetic inflammation of the mucous membrane of the lungs.

Organs connected in function usually exert an influence of this sort over each other. One eye being inflamed, the other is seldom entirely sound. Grateful impressions made upon the tongue and palate induce a sympathetic increase of secretion in the salivary glands; and the impressions of light in the retina determine in a similar way the contractions of the iris.

An active sympathy is remarked between *remote tissues of a similar structure.* The mucous membrane of the alimentary canal is morbidly affected by diseases of the mucous membrane which lines the kidnies. Hence vomiting becomes a symptom of the passage of a stone through the ureters.

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* Cicero defines συμπάθεια to be an action arising "ex conjunctione naturæ et quasi concentu atque consensu."

De Divinat. l. i.

The explanations of modern philosophers have not been more felicitous.

Lastly, sympathies occur between organs having *no known connection of structure or of function*,* as when the toe is inflamed from gouty irritation in the stomach.

Beside these sympathies of tissue, others more general and pervading subsist between the several great viscera; by means of which each influences the other, and has, as it were, a voice in the government of the whole machine. The sympathetic affections of the stomach and intestinal canal are pre-eminently remarkable. Derangement in the functions of the alimentary tube produces head-ache, turbulent dreams, and various hallucinations; and is one very probable cause of hydrocephalus. It disturbs likewise the arterial system, exciting the heart to quick and irregular pulsation; it throws the muscles into various spasmodic contractions, and induces some varieties of asthma.† The alimentary canal maintains also a close connection with the skin; in consequence probably of their continuity of surfaces and general similarity of organization.

On the other hand, the stomach is itself influenced by the action of other viscera. Thus a concussion of the brain, or even a strong mental emotion, is sufficient to produce vomiting; and diarrhœa is not an unfrequent concomitant of grief. There is indeed scarcely a morbid affection, whatever may be its seat, in which the stomach and intestines do not largely participate. Hence Aretæus has justly observed, Στομάχος ἡδονῆς καὶ ἀηδίης ἡγεμών, that the stomach is the great source of pleasurable and painful affections.

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* Bichat. † Hamilton on Purgatives. Bree on Asthma.

The sympathetic operation of the great viscera, in determining the character and passions of individuals and species, remains yet to be studied by metaphysicians. The influence of certain morbid conditions of the liver in exciting peculiar trains of ideas is, however, well-known, and physicians have noticed the opposite effect of pulmonary consumption, in raising the spirits, inducing sanguine anticipations of the future, and illuminating the path to the grave with the ignes fatui of incipient dissolution. The total revulsion of the whole animal at the epoch of puberty; and the irresistible impulse of the instinct of maternity are beautiful illustrations of the same law.*

To the sympathetic influence of particular organs upon the brain must be attributed all those actions which animals perform at stated seasons, and under the influence of peculiar physiological conditions; such are the nidification of birds, the temporary ferocity of the male of some herbivorous species, a vast variety of singular tendencies in the insect tribes, and the increased moroseness of carnivorous animals when excited by hunger.

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* Cabanis Rapport du Physique et du Morale de l'Homme.

The existence of this last influence, even on man, is well known to those who have closely studied human nature. There are few persons not aware that favours are most easily obtained at the moment when the temper is softened by the pleasurable sensations, which result from a satisfied appetite, and an easy digestion. By this sympathetic influence of the nutritive organs upon the mind, even national character is in no slight degree affected. Habits of long continued and ever-pressing misery beget a ferocity of disposition, and an indifference to vice, by the prevalence of uneasy sensations; while the agreeable excitement of healthy functional action, which results from an adequate supply of the primary necessaries of life, promotes the gentler feelings, and knits more closely the ties of society, by predisposing the individual to sympathize with the pleasures of the species. This is one of the physical bases of that intimate connection between a beneficent government and an obedient population; and it helps to explain the certainty of that destructive reaction, which, from time to time, sweeps the tyrants of the earth from its surface, and strikes the sanguinary balance between despotism and slavery.

All these movements, which are essentially necessary to the preservation of life, and which take place without the intervention of a specific volition directed by intention, must depend upon an original sympathy connected with the organization. Thus the impression of air on entering the world excites the diaphragm to its contraction; and the impression of the effluvia of the milk induces the first efforts at sucking, immediately after birth, without any effort of the will, or of any other known principle of action. The natural expressions of passion, which form the basis of artificial language, and without which it could not subist,* are in like manner independent of imitation and undirected by consciousness; they are movements sympathetically excited by definite modifications of sensorial impression, and as they fall equally upon the automatic and relative organs, are manifestly unconnected with volition.

It may be imagined that in attaching the phenomena of instinct to the general law of sympathy, real knowledge is very little increased; as one unknown cause is merely substituted for another. This may, to a certain degree, be true: but if, in allying the instinctive movements to another order of well-known phenomena, some portion only of vagueness and mystery belonging to that term be banished, the advantage which philosophy would derive from the arrangement will not be trifling.

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* Degerando, Des Signes.

The benefit, however, is much more considerable, since this view of the subject reunites the two classes of voluntary and instinctive actions, which have been most injudiciously separated; for what are reason and volition but sympathetic actions of the nervous organs, induced by their necessary and fundamental connection with the organs of sense? Given sensations produce definite ideas; and the sum total of ideas present in the intellect originate definite reactions of the will, as certain and as unerring as any that are purely instinctive. The principal difference appears to consist in the greater rapidity of instinctive motions, a rapidity which is incompatible with consciousness.

The sympathies which result from the healthy discharge of function, contribute for the most part to the preservation of the machine. Such are the movement of the diaphragm in sympathy with the lungs; the instantaneous developement of nervous vigour in consequence of the presence of food in the stomach, &c. &c. Those sympathies which take place in disease have rarely the same happy tendency. The spasmodic contractions which supervene in certain affections of the bowels, and constitute *cramp*, serve only to aggravate the disease. The same remark applies to the pain in the shoulder, accompanying diseased liver, the head-ache from deranged stomach, vomiting in affections of the kidney, &c. Here then may be found another argument against the supposed vis medicatrix naturæ. These sympathetic movements are the necessary results of a general law, which may or may not be beneficial, according to the coincidence of other circumstances; and they are evidently instituted without any specific design, such as should flow from a curative principle in the animal mechanism.

The sympathies, which result from morbid affections, may exhibit themselves in sensations, in muscular motions, or in affections of the nutritive system. Of all these modes of sympathy, instances have been already quoted. In the gouty affection, sympathetic of a peculiar derangement of the stomach, the whole three are evinced in the pain, cramp, and inflammation, which constitute the disease.

Various attempts have been made to explain sympathy by nervous communication, by connection of blood-vessels, and by connection of cellular substance ;* but it is evidently a primitive law of organization, which admits no other explanation than that which shall unfold the mystery of life itself. Thus much is certain, that the influence of impressions is more extensive, in proportion as the general vitality of the species is more exalted. The reference of sympathy to nervous influence is the explanation of a general by a partial fact; and it would be much more logical to explain nervous influence by sympathy, if the one form of expression could be rendered more intelligible than the other.

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* Sympathies occur between parts not at all connected by nerves, and which do not receive their blood from the same vessels. The connection by cellular substance is too general to account for any partial facts: each of these explanations is therefore defective.

One probable source of sympathetic pains may be an error of perception, by which the sensorium falsely attributes pain to a sound organ, remote from the seat of disease. Similar errors occur in delirium, and in certain other unknown conditions of the brain, resembling hypochondriasis, by which the imagination confers a reality upon its dreams, equal to that afforded by actual sensation. Many patients, on the approach of the epileptic paroxysm, imagine the appearance of some horrible figure, which, as they fancy, strikes them at the instant of their fall. This morbid affection has been ingeniously applied to explain the testimony, which persons even of superior endowments have given, respecting apparitions, and other phenomena, in their own nature impossible; and concerning which no testimony would produce conviction in a sound reasoner.

There yet remains to be considered one other natural sympathy, of which however much cannot be said. It is that which exists between the individuals of the same species, or of those which are nearly allied. It exists most extensively in the higher classes of animals, and diminishes gradually in descending the scale.

In its lowest degree, it seems to belong only to those movements which are connected with the preservation of species: in the highest, it extends to every emotion, of which the mind is susceptible. Between two human individuals whose affection is genuine, the sentiments are rather conveyed by glances, than expressed by words; and emotions are reflected and participated by tokens, more precise, more delicate, and more certain, than those which are merely conventional. It is the superior susceptibility of man for these impressions, and not the organic arrangement of his instruments of speech, which has originated his system of artificial signs. The conventional language of the deaf and dumb evince, that speech is not the necessary condition of social communication, although it affords the readiest and most complete medium of mental intercourse.*

The sympathetic influence of man upon man acts, as material agents do, in virtue of the mass. The assemblage of a large crowd of human beings is, in itself, an agitating circumstance, and when they are thrown into movement, affects the senses independently of any acquaintance with the object or passions of the multitude. The emotion of Xerxes at the sight of his assembled armies was perfectly natural; and is therefore entitled to credit as an historical fact. When a sentiment is disseminated among an assembly, the greater the number of persons, the more certainly uniform are their motions. The orator addresses only the few who surround him: they alone can hear his reasons, or be moved by the working of his passions: but his emotions are propagated *deproche en proche*, to the most distant individuals; and rage, indignation, or fervent devotion are disseminated, as if by an electric communication.

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* Dogs, horses, and other domesticated animals, read the natural expressions of the human countenance, and thereby maintain relations with man even closer than with their own species. This is the whole theory of sagacious dogs, learned pigs, &c. which, by means of the language of nature, are made to comprehend conventional signs, and to connect them with definite actions.

Upon these facts is founded the bare-faced and abominable charlatanerie of mesmerism, or animal magnetism. The nature of the deception is fully developed, by the counter-experiments of making the subject of trial believe that he is mesmerized, when in fact he is not; and of performing the real process upon him without his knowledge. When the mind is disengaged, no effect is produced; and when it is possessed by the experimentalist, the effect follows without the intervention of its pretended cause.

Besides the sympathetic connections, which naturally subsist in the economy, others arise during the exercise of function, by a law which has obtained the name of ASSOCIATION. Whenever two or more organs have acted frequently together, or in sequence, their functions become so far connected, that the action of the one, necessarily calls the other into immediate play. All the ordinary motions of the limbs are thus produced; the several muscles which conspire to any movement, are, in the first instance, independent in their action; and their simultaneous and congruous contractions are determined by a deliberate exertion of the will, accompanied by a painful attention to the process. When, however, these efforts have been many times employed, the muscles acquire an habit of acting together, with promptness and precision, in the exact order, force and extent, necessary for the performance of the motion required.

Each step of the process being thus instigated by the preceding one, it requires no specific voluntary impulse, but is carried on independently of the will; and may be continued without the attention of the animal.

This law is not confined to the contractile fibres, but operates also in the sentient tissues. An experienced organist, who is a sound musician, will not only execute rapid passages, but will pursue the intricacies of an extempore fugue, while his attention is engaged in conversation; the ear suggesting from each chord, that which is to follow; and the finger executing the requisite movements, without the consciousness of the pre-occupied performer.

The influence of association, in determining muscular movements, impairs very considerably the exertion of volition. Every day's experience exhibits the difficulty of breaking down bad habits, awkwardness of gait and gesture, and ungraceful and inelegant tricks.

The obstinacy, with which associated motions remain connected, is manifested in the difficulty of learning to speak foreign languages, or of acquiring dexterity in manual exercises, in mature life. The maxim of *nulla dies sine linea* is founded upon this physiological law; and is applicable alike to all our labours and all our acquirements.

The influence of different stimuli upon the living machine is by no means uniformly alike. Some substances act specifically on the part to which they are applied, or upon some others sympathetically connected with it. Thus emetic drugs render the movements of the stomach retrograde; cathartics act almost exclusively upon the intestinal canal; turpentine and cantharides principally affect the kidnies, and mercury exerts its greatest influence on the glandular system. There are other substances whose operation is more general, on which account they are known by the appellation of *diffusible stimuli;* such as wine, opium, æther, &c. The substances of this last class appear to derive their extensive agency in the system from their effect upon the cerebral tissues, and not from any thing peculiar in their mode of action. Some stimuli, which make but a trifling impression upon the tissue, with which they are in contact, induce violent action in some remote part. Thus, tickling the throat with a feather produces a convulsive heaving of the stomach; and a few drops of the essential oil of bitter almonds applied to the tongue suspends instantaneously the functions of the brain.

When a stimulus of any strength or durability is applied to a living tissue, its capillary vessels are thrown into a state of increased action; and more blood is received by them from their corresponding arteries, than they usually circulate. If a thorn, for example, be buried in the flesh, the surrounding capillaries are immediately distended with red blood, producing the inflammatory blush on the skin; an increased quantity of serum is likewise effused into the cellular tissue, occasioning considerable tumefaction; and pain is felt in the seat of irritation, which indicates an increase of sensibility:—in short, all the nutritive functions of the part act with a preternatural vigour and rapidity. These effects occur, though in a lower degree, whenever any particular organ is called into extraordinary exertion.

By the operation of this law, the balance of the circulation suffers perpetual changes; each organ becoming, in its turn, the seat of an increased determination of blood, as it is called into action, in the business of the economy. The necessity for this arrangement is self-evident. The vitality of the tissues is not a substantive quality, but depends upon the constant accession of arterial blood. It follows, therefore, that there must exist a connection between the supply and the demand. If the stimuli, which excite to the discharge of function, did not likewise rouse the nutritive vessels of the organ to an increased action, the vitality of the part would rapidly be exhausted; and the organ would fall into a state of more or less permanent debility upon every trifling exertion.

The disposition to orgasm, or to this excited condition of the vascular system, is not equal in all organs, being the most easily produced in such as are the most independent of the cerebral centre. The eye will bear the stimulation of a strong light for a very long time before it is thus thrown into inflammatory action; and many hours of mental labour pass away before the head-ache and flushed countenance occur, which indicate that the brain is receiving a disproportionate supply of the circulating fluids.

It is not improbable that the recurrence of certain diseases is in some way connected with the periodical orgasm of peculiar viscera, induced by the repetition of daily habits. Thus epilepsy is apt to occur during sleep; and some species of head-ache are manifestly connected with peculiar conditions of the stomach.

It is very rare that two organs become simultaneously the centres of fluxion; a marked action in one part being rather a reason for the quiescence of the others. Study, or great mental excitement, commenced immediately after eating, produces an imperfect digestion, by forcibly rendering the brain the seat of orgasm; while, on the other hand, a full meal, by rendering the stomach the centre of fluxion, produces a confusion of ideas, and an inaptitude for motion which can only be shaken off by a violent effort of volition. When, therefore, two organs are simultaneously stimulated, either the one becomes a centre of fluxion, and the other ceases to respond to its stimulus, or both are thrown into irregular and imperfect action.

The alternation of action between the skin and the kidnies, occasioned by variations in the temperature of the atmosphere, affords a familiar instance of this law.

The chilly sensation which persons of delicate constitution experience after eating, depends upon the same cause: for the abdominal viscera then becoming the centre of fluxion, the skin falls into a state of comparative exhaustion; and its circulation being thus slackened, less heat is evolved at the surface. For the same reason, the nerves, on the other hand, react less vigorously upon the stimulation of atmospheric temperature; and consequently propagate to the sensorium a sensation which usually proceeds from a positive diminution of heat.

By the same principle may be explained the very singular fact, that great mental excitement suspends or supersedes the impressions of bodily pain. It elucidates, also, the relief which soldiers seek under punishment, from forcibly biting a bullet. In the latter case, the whole force of volition is expended in exciting the maxillary muscles; and by thus rendering the brain, in some degree, a centre of fluxion, it diminishes the irritability of the tissues, which are torn by the lash of the executioner.

It is upon this principle likewise that blisters operate in relieving internal pain, and that a vigorous slapping of the palms of the hands diminishes the force of the hysteric paroxysm. Nature itself points to this mode of relief in the natural movements of affliction, which seeks a respite from mental agony by painful impressions made upon the body. The critique of Bion, the philosopher, upon that line of Homer in which Agamemnon is represented as plucking out his hair in sorrow, is singularly unhappy.* "Perinde stultissimum regem in luctu capillum sibi evellere, quasi calvitio mœror levaretur."† These movements of tearing the hair, beating the breast, &c. are instinctive, and the poet has followed Nature closely in thus describing the vehemence of grief in the self-willed monarch. Under the influence either of grief or of anger, such violent actions are sought as a counterpoise to the emotion; and the tendency shews itself in various overt acts, according to the prevailing disposition at the moment. The Jewish custom of rending the garments on the decease of friends is founded in this natural expression of sorrow; though, like other established customs, it has become purely conventional; and is rendered ridiculous by the persons of that persuasion cautiously putting on their worst clothes when a member of the family is known to be lying at the point of death.

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* Πολλὰς ἐκ κεφάλης προθέλυμνους ἕλκετο χαίτας.

† Ciceronis disput. Tusc. 26. Ed. Davisii.

The effects of stimulation on the sentient fibre are, then, first, the direct exhaustion of vitality; and secondly, an indirect accumulation of it, by the intervention of the circulating system. The class of diffusible stimuli which sympathetically excite the nervous organs, and, through them, increase the vigour of the heart's pulsation, exert this second influence to a remarkable degree. Upon this fact rests that part of the Brunonian practice of medicine, which consists in supporting the constitution, in diseases of debility, by the regulated application of this class of stimulants, until the body re-acquires the necessary vigour, for continuing its functions, unassisted by art.

The power of thus exciting the nervous system is not indefinite, the nervous tissue itself becoming ultimately exhausted by the process. Great delicacy is therefore necessary in administering the doses of these remedies, in order to preserve a constant and uniform reaction in the constitution; neither suffering the influence of the drug to become excessive by too frequent or too liberal use; nor allowing it altogether to subside by a too tardy or insufficient re-application.

When an excessive dose of a diffusible stimulus is taken, its first effect is to develope a vast increase of sensorial power. Under these circumstances slight and ordinary stimuli produce powerful and disproportionate effects. The ideas, generated by the slightest impressions, succeed each other with a rapidity that hurries them beyond the control of judgment.* Thus it is that wine calls forth the passions, and lays bare the weak side of character. The associated movements are likewise excited with an increased facility; the imagination acquires a temporary brilliancy, and the bon mot and repartee flow with less effort, and are more poignantly enjoyed.

By degrees, however, the intellectual movements proceed with a still greater rapidity; the ideas are less perfectly formed, and lose their connection: the cerebral reaction of volition becomes irregular; the muscles act feebly; the speech consequently faulters, and the power of locomotion is partially or entirely suspended.

This excess of stimulation, in the mean time, inverts the muscular action of the stomach; whence there results a sympathetic vertigo that is soon followed by a deep and heavy sleep, during which the influence of the drug gradually subsides. It is seldom, however, that the movements of the machine entirely recover their regularity in less than four-and-twenty hours; during which time, those who are unused to this excessive stimulus, suffer a slight paroxysm of fever, with head-ache, nausea, and frequently an inordinate secretion of bile.

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* Darwin—Zoonomia.

During the period which immediately succeeds the excitement of intoxication, the uneasy feelings of exhausted sensibility are very distressing; and nature, by an unfortunate necessity, impels the drunkard to seek, in fresh excesses, a relief from imperfect excitement. The wretched victim thus becomes the slave of an habit which acquires strength at each repetition.—A load of mental and of physical suffering presses upon him in the moments of sobriety, which becomes gradually less endurable; and he rushes upon renewed inebriety, to quiet a nauseating stomach and an accusing conscience.

A very inordinate dose of these diffusible stimuli, it is almost needless to add, destroys life *instanter.* A pint of undiluted spirits, taken at a draught, has been known to kill, as by a flash of lightning; and in this agency they are more merciful than in the varied and more protracted torments, which, when taken in smaller quantities, they inflict upon the habitual drunkard, as they no less certainly drag him down the "dusky road to death." Yet into this path are whole nations seduced, in order that the state may derive a revenue; though it be purchased by a multiplication of hospitals and gibbets, and at the expence of the industry, health, and morals of the deluded subject. For man, "deck'd in his little brief authority," disdains subjection to reason, and continues to the end deceiving and deceived; with religion and morality for ever in his mouth, yet ever encouraging by his institutions the multiplication of crime; punishing with one hand what he solicits with the other, and arming heaven and earth against enormities, which spring from his own ignorance, and are fostered by his own perversity!

Contrasted with the diffusible stimuli in their effects, are those substances which excite a less remarkable but more permanent action on the system. Of these the conchona bark is the most powerful. The manner in which these drugs operate is altogether unknown. The appellation of *tonic*, which is conferred upon such medicines, is founded upon notions obviously false; as there is nothing in the organized constitution, analogous to *tone*, or elastic tension. By many persons the operation of tonic vegetable substances has been attributed to their chemical union with the living fibre, in a manner analogous to their combination with the skin of dead animals, in the process of tanning. *Tannine* however is not an universal ingredient in tonic medicines, nor does experiment evince a real condensation of substance, in persons restored to health by the use of these remedies. Their operation indeed is obviously vital; but whether it falls upon the minute capillary system, or is exerted upon the stomach, and through that organ sympathetically on other tissues, is by no means clearly ascertained.

THE REACTIONS of the contractile tissues upon the application of stimuli, vary according to the nature of the organs, and the functions which they are destined to perform. In the muscular tissue, which is the most open to examination, they consist in visible contractions of the fibres, by which these organs are longitudinally shortened, and acquire a corresponding increase in their lateral dimensions. In this condition, the cohesion of their integral parts is exceedingly increased. For muscles, which sustain great weights, when thrown into action, are easily ruptured, by distending forces, if applied in their relaxed condition.

The habits of the different muscles with respect to contraction are considerably various. Sphincter muscles, which guard the orifices of internal cavities, remain permanently contracted, when not distended by opposing causes; so also the muscular coat of the stomach and that of the bladder exert a gentle pressure upon the contents of those organs, in every state of repletion. In the muscles of loco-motion, contraction is not a permanent condition, being maintained with ease, for a few seconds only at a time. Even in this short interval, the fibres are not uniformly contracted; but pass individually into alternate states of contraction and relaxation; which, in long protracted efforts, and more especially in persons of feeble constitution, causes that tremulous motion of the limbs accompanying their movements.

A continued exertion of the muscles causes fatigue, which is accompanied by a difficulty that rapidly increases, of continuing their action. There is, however, some difference between the different muscular organs in this respect. Those which are subservient to the nutritive functions, such as the heart and diaphragm, are preserved through life in a constant alternation of action and repose, and they admit of but very slight variations of intensity. But those muscles which obey the dictates of volition, are necessarily liable to great variations in the quantity of their action. They become, therefore, like other organs of occasional activity, the seats of a local orgasm, the centres of fluxion, from which they derive a temporary increase in their living powers.* The first efforts at muscular motion are therefore never so vigorous as those which occur after the orgasm has, for a certain time, subsisted. In the end, however, the maintenance of this condition tends to induce inflammation; the first approaches of which are marked by that painful sensation we term fatigue—a sensation closely resembling rheumatic pains. Under the influence of diseased excitement, the muscles may be thrown into spasmodic action; consisting either in quick alternations of contraction and relaxation, or in permanent and immoveable contractions; of which the two diseases, St. Vitus's dance and locked jaw, afford familiar instances: and it is somewhat singular, that in the last of these diseases, the blood exhibits the marks of excessive inflammatory action; as if the protracted contraction of the muscles had excited a real inflammation in those tissues.

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* Parke in the Journals of the R. Institution.

The phenomena of nutritive contraction are too far removed from inspection to admit of satisfactory details. In the processes of nutrition and of secretion, the solids are evidently active; their office not being confined to a mere percolation of the fluids. But the nature of this action admits not even of a guess; the ideas connected with the term contraction are very vague, and are only so far just, as they refer to the mere propulsion of the fluids through the capillaries.

The regularity of stimulation in the organs of nutrition, (arising from the concatenation of their functions,) and the readiness with which they are rendered centres of fluxion, subtract them, to a great degree, from the necessity of periodic repose. As far as they are susceptible of influence from external causes, they may be goaded into inflammation, or depressed into languor: but in the intrinsic exercise of their functions, they do not so far exhaust themselves, as to require occasional suspensions of action to fit them for the continuance of life.

But the immense variety of objects, with which the organs of relation are connected in action, induces, at every instant, changes more or less violent, in their quantum of excitement. Let the situation of a prisoner, debarred from exercise, without books, light, or amusement, and shut out from the major part of the natural stimuli of the senses, be compared with that of a man moving through the crowded streets of a great city, transacting important business, frequently changing the scene and the subject of his exertions, and enjoying, in succession, the feast, the theatre, and the assembly; and it becomes manifest, that another law of action is necessary to meet such opposite conditions, than that which governs the movements of nutritive function.

The tissues subservient to the relative functions, admit, therefore, a much more considerable latitude of stimulation, without being thrown into inflammatory action; and are susceptible of long continued exertions, without undergoing a more violent state of orgasm, than that which constitutes fatigue. The sum total of their daily excitement is, however, greater than could be supported for a continuance; and it is maintained by the interposition of periods of repose, during which the animal functions remain in a more or less perfect abeyance.

The nature of SLEEP has been variously considered by different physiologists. By some it has been regarded as a definite function; but as the term *function* is equivalent to action, it is a manifest abuse of language to apply it to a state which consists essentially in the negation of action. By other writers sleep has been regarded as depending upon a variation in the balance of circulation, during which the blood is accumulated in the veinous vessels of the head. This position, drawn from the analogy of apoplectic stupor, seems particularly deficient in probability; inasmuch as it assimilates "tired nature's sweet restorer" to a most dangerous and fatal malady. The state of the circulation through the brain, during sleep, is wholly unknown, nor have any facts been ascertained concerning the mechanism of this condition, to warrant any decided opinion on the subject. Thus much, however, is known, that sleep does not necessarily fall upon all the animal organs simultaneously. When any one of them has been more particularly excited, it may repose, while the others are awake. Thus the imagination is often active, while the organs of sense are closed and at rest; forming a condition abundantly familiar, under the denomination of DREAMING. Frequently, also, one or more of the senses remain awake, whose suggestions, mixed with those of the imagination, arouse volition, and produce the phenomena of SOMNAMBULISM. Perfect repose, therefore, instead of resulting from any definite function of one tissue, is rather an assemblage of many partial sleeps, each of which arises out of the condition of its own immediate seat.

The several animal organs do not, in general, fall simultaneously into quiescence. The organs of sense are ordinarily the first parts to sink into repose; this necessarily suspends volition, and then the muscles relax; (an epoch marked by the dropping of the head, when sleep supervenes on persons in the upright position;) and lastly, the functions of the sensorium are suspended, when the sleep becomes perfect and complete. Dreams, therefore, which consist in movements excited by internal impressions, or by stimuli applied to the senses, while in a state of imperfect repose, occur principally during the first moments of sleep, and immediately previous to awakening.

The periodical alternations of sleep and of exertion seem to depend, in a great measure, upon habits induced by the superior convenience of reposing during the night. The hours of darkness are ill-suited to the occupations of life; while, on the other hand, the abstraction of light and heat, occasioned by the absence of the sun, favours the approach of sleep, and renders night the properest season for habitual rest.

This connection of night and repose becomes, by inveterate custom, in a great degree essential to health. The observance of irregular hours, whether for the purposes of debauchery, or of literary lucubration, predisposes to disease, by disturbing the diurnal revolution of catenated actions. That night sleep is not, however, absolutely and intrinsically necessary, may be inferred from the habits of certain animals. Beasts of prey are usually alert during the nocturnal hours. For, as with the human race, "ut jugulent homines surgunt de nocte latrones," so do the robbers of the brute creation exercise their cruelty and rapacity with the greatest effect under the shelter of darkness. Besides the moral advantages derived from an attack made upon a sleeping victim, or upon one suddenly roused from repose, and perplexed by the surrounding obscurity, the predatory animals have a physical superiority by night in the structure of their eye. Their retina is, for the most part, so powerfully stimulated by small quantities of light, that they do not enjoy a perfect vision during the glare of day; but see most distinctly by the partial glimmer of evening or of night; and the obscurity which bewilders other animals, assists them in discovering and securing their prey, and thus determines their peculiar habits of nocturnal watchfulness.

But a more conclusive argument may be drawn from the health of those persons who are driven by the necessities of society to exercise their industry during the night. The guards and drivers of night coaches, when they have once broken through the habit of nocturnal repose, appear to enjoy nearly as good health as other persons, provided they do not indulge in the abuse of spirituous liquors; and soldiers on active service, after a little seasoning, take rest as opportunity permits, without suffering in health by the night marches and watching, incidental to the duties of their arduous profession.

The partial sleep of separate organs is most obvious to notice, when the pressure of accident first breaks through acquired habits of periodical rest, and carries the exhaustion of animal sensibility to its maximum. In this state the individual organs close, one by one, as soon as they cease to be actively employed. During the night marches of the memorable retreat upon Corunna, the soldiers are said in some instances to have slept in the act of walking, (so completely were they exhausted by fatigue,) and thus to have got in advance of their regiment by not noticing the halt of their companions. In these cases, one sense alone, perhaps, remained awake to influence the will, while the rest sunk under the disproportionate exertion into a forced repose.

A continued suspension of sleep debilitates the frame, and causes a rapid waste of the substance of the body: fat persons are uniformly sound sleepers. After a certain time, the necessity for repose supersedes every effort of the will to rouse attention. Women, during tedious labours, sleep heavily between the pains of parturition; and criminals have been known to doze, amidst those more protracted tortures of the question, which a barbarous and besotted policy has inflicted upon its victims, under the specious appellation of justice.

As sleep may be for a time prevented by the application of stimuli, so it may also be dissipated by a morbid superabundance of excitability. This condition occurs in maniacal cases and in fevers, in consequence of an undue determination of blood to the head; which is indicated by a flushed countenance, and an animated yet glaring eye.

When the sentient tissue is thus thrown into a state of orgasm, the organs of sense are induced by slight internal stimuli to repeat those actions, which ought only to be called forth by external impressions; and thus, by originating ideas which have no external prototypes, they occasion delirium. In these cases, the admission of day-light, by giving real impressions, sometimes supersedes the delirious imaginings: but if the orgasm be more violent, it will rather increase delirium, in consequence of the excessive re-action of the brain, which produces pain, calls up remote associations, and repeats innumerable movements, from the stimulus of the slightest external images. In these cases sleep is the natural cure for the disease, or rather its presence marks the fact, that the morbid excitement has already abated.

The necessity for thus suspending the relative functions in sleep, renders the sum of animal life much less than that of the organic. By far the greater portion of infancy is lost in the oblivion of repose. The sensorium, as yet unaccustomed to work upon acquired ideas, is alone stimulated to action by sensitive images; and the infant has only to close its eyes and to sleep. At this time of life, also, the blood is principally expended in the processes of nutrition; and the relative organs have not acquired that predominance in the system which enables them to support a protracted watchfulness. In proportion as the frame becomes developed, less sleep is necessary for health. In the acme of life, from one fourth to one third of the four-and-twenty hours is amply sufficient for maintaining the body in full vigour. Many persons indulge only in the refreshment of six hours repose; which, however, is scarcely sufficient to prevent some degree of emaciation. In old age, which in so many other respects resembles infancy, a greater quantity of sleep again becomes necessary. Thus something more than one third of existence is passed in inactivity and virtual death; and the duration of internal life is nearly double that of external or moral being.

Although the cooling freshness of the night air is favourable to sleep, a greater degree of cold, by inducing pain, is a frequent cause of watchfulness. Intense cold, on the contrary, by the rapid exhaustion it occasions of sensibility in the effort to maintain the animal temperature, irresistibly disposes to stupor and sleep. There are, however, among the different classes of animals, certain families upon which a reduction of temperature, far less than that which destroys life, produces effects analogous to sleep, which are known under the name of HYBERNATION. These animals, upon the approach of winter, seek out some retired spot, generally under ground, and partially secluded from the atmosphere, where they may remain uninterrupted, until the genial season of spring returns and rouses them to a new existence. In the intervening time they sink into a state of profound repose: they eat nothing, they breathe at long intervals, their pulse slackens, and their temperature sinks below its habitual standard, although it still remains higher than that of the surrounding atmosphere. Digestion is at a complete stand; as Spallanzani proved by direct experiment. If the animal be fat, (as is usually the case at the commencement of hybernation,) it becomes lean during the continuance of the confinement; its substance being expended in the maintenance of life.

The causes which predispose to hybernation, like those of so many other general facts in physiology, are unknown. The phenomena occur in animals, so various in structure, yet so little different from their non-hybernating congeners, that the peculiarity seems altogether independent of visible and tangible organization. It is a curious fact, (if it be true,) that swallows, which usually avoid the severe winter of our climates by an annual migration, are also capable of hybernation, if accident prevents them from joining the general expedition, and forces them to remain behind their companions. Of this fact many instances were cited during the ardour of a literary contest, conducted in the pages of the *Gentleman's Magazine;* and the authenticity of the facts seems almost past denial. But the same evidence likewise exists of the inclosure of living toads in solid blocks of marble, and of facts even still more incredible. Human testimony is of so little value, even on the plainest and most common-place circumstances, that it cannot be received with sufficient caution. To doubt is the beginning of wisdom; and scepticism the safest clue to conduct through the labyrinth of error, in which the foundations of science are for most part involved.

The occasional suspension of activity in vegetables, indicated by the closing of their leaves and petals at the approach of night, or of wet weather, and which is termed their sleep, may, with more propriety, be likened to hybernation: for these phenomena are more immediately connected with the abstraction of those stimuli, by which the vegetable circulation is suspended. Many plants, also, appear not to respire in this condition;* a circumstance in which it differs materially from the sleep of animals.

Although the nutritive functions are not suspended during sleep, they suffer some diminution of rapidity. The movements of the muscles and the impressions made upon the senses in the waking condition, communicate a certain degree of stimulus to the circulation. The absence of these sources of irritation, during the repose of the relative organs, slackens the rapidity of the pulse, but at the same time that it becomes slower, it is rendered more full, and the blood is more decidedly propelled to the capillaries. These vessels therefore assume a slight degree of orgasm, and perform their functions with more freedom and force. This fact is proved by the increased perspiration incidental to sleep, by the growth of the body being then chiefly effected, and by the more rapid healing of wounds and convalescence from disease at that period, than during the hours of watchfulness and action.

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* Darwin's Phytologia, iv. 5. 5.

This incapacity for sleep, which characterizes the nutritive organs, is not without considerable inconvenience in the general economy. When circumstances induce an inordinate action in parts of relative function, the balance is restored by a consequent sound sleep, a gracious remedy, producing a complete reinstatement. Excessive excitement in the nutritive system admits no such healthy principle of restoration, but is followed by inflammatory reaction, or by diseased languor. This law would be of little consequence if the organic being, in itself *totus teres atque rotundus*, suffered no extraneous impulses from the external world. But deriving the materials of its functions from food, administered according to the affections of the percipient being, it partakes indirectly of the caprice of volition, and of the aberration of appetite; and it is thus exposed to the irregularity of action, proper to the relative organs, without the same means of obviating its consequences. Vegetables and Zoophytes are subject to few diseases; and those mostly the results of accidental violence; while the higher orders of animals become subjected to malady in proportion as the character of their animality is exalted, and the physical more subjected to the moral being. The sensual gratification of appetite is usually characterized as brutal—a most unjust libel on the subject of the comparison. Inordinate gratifications of sense are the fatal prerogatives of reason ; and the further an animal is removed from the human organization, the purer are its habits, and the more healthy its life.

CHAPTER V.

MENTAL PHENOMENA.

RELATIVE sensibility dependent on the same causes as organic life—No centrum commune—Each tissue has its own mode of sensibility—Ideas do not resemble their prototypes—The belief of an external nature makes part of perception—Sensations alike in all individuals—The reaction varies—Retention—Association of ideas—Memory, imagination, judgment, abstraction, invention, different modes of Association—Instinctive and voluntary or reasonable acts, proceed from the same mechanism—The distinction arises out of two modes of viewing the same fact—Pain and pleasure, the great motives of action; also defect of stimulus—The passions—Their connection with organic life—Pseudo-passions, ennui—Sympathy with sensitive beings a motive of action—All organized action necessitated—Passions not subject to the will—How controlled—Influence of education—Sudden changes of character—Repentance—National character—Sensitive and remembered impressions, how distinguished—Recollection independent of the will—Mechanism of memory—Of Reason—Language--Analysis--Synthesis—Judgment--Syllogism—Delirium--Drunkenness--Recapitulation--Estimate of the comparative powers of animals; and of men amongst each other—Ideot, dolt, common man, genius, eccentric, lunatic—Universal genius—Theory of life, origin, &c. of the spiritual system—Reasons for rejecting both a spiritual and a material principle of life.

CHAPTER V.

MENTAL PHENOMENA.

Hos tenues nexus, obscuraque vincula quædam,
Detegere, et rerum mysteria pandere, frustra
Tentavit mortale genus. Nostræ abdita menti
Hæc animæ compago latet semperque latebit.
Jamque ruunt diu celebrata systemata, nobis
Unica tantarum manet ignorantia rerum.

Steph. Lud. Geoff. de Higiene.

Ἠδὲ γὰρ μοὶ σκότος ἄγνοιας ἄπαντα, καὶ ἀπάτη μελαίνα, καὶ ἄπειρος πλάνη, καὶ ἀτελὴς φαντασία, καὶ ἀκατάληκτος ἄγνοια.

Hermiæ Irrisio των εξω φιλοσοφων, *sub finem,*
Just. Martyr. Operum, Par. 1636.

RELATIVE sensibility, a faculty supplementary to the nutritive functions of animals, and arising out of their necessities, places the individual in connection with the objects of external nature, and enables it so to act upon the substances, by which it is surrounded, as to contribute directly to its own permanence and well-being.

Essentially linked with the power of locomotion, relative sensibility is distributed to the different animals, in an exact proportion to the wants of their organization, being resident in a tissue, whose developement is regulated in the various species, by the sphere of activity necessary to their preservation.

The intimate nature of this function, like that of all other primary organic movements, is placed beyond the reach of our present means of investigation ; but there is no well-grounded reason for supposing that the phenomena it exhibits differ from other physiological movements, or require the existence of other principles than those which contribute to organic vitality. The operations of external bodies upon the organs of sense are analogous to those of the appropriate stimuli of other tissues ; the vitality upon which they act is derived, in common with that which animates other organs, from the blood ; it obeys nearly the same laws, is increased and diminished in intensity by the same causes, and in every respect preserves a similarity of action, which cannot leave a doubt of its identity with the great cause of organic existence.

Anatomists have expended much labour in the dissection of the brain : minute differences of form and arrangement have been noticed with industry and fidelity, but no corresponding knowledge has been obtained respecting the functions of the subordinate parts. Almost every distinct portion of the brain has been found, in different subjects, in a state of disorganizing malady, without any determinate corresponding derangement in the mental functions.* On the other hand, insects and the other similar animals, whose cerebral organs are but little developed, seem to feel, and to reason with precision upon the facts which their organization presents, and appear to differ from the higher races in their faculties, rather in the number of their perceptions than in the modes of their reactions.

But if the link between organization and function, in this instance, escape from observation, it is a most vitious and feeble conclusion to suppose that it does not exist. To adopt this mode of reasoning is to suppose that the cerebral tissue exists without any precise and definite function, and that it is wholly supererogatory in the economy; a proposition which, independently of its absurdity, is manifestly false; for there are certain limits, beyond which these organs cannot be deranged without the total obliteration of the faculties. To judge from dissection, the affections of the vascular system of this tissue exert an immediate and despotic influence over its functional powers. Very small increments in the force of circulation through the brain, (evinced by a trifling increase of the apparent vascularity of its membranes), are concomitant with considerable derangements of function; and a slight degree of pressure in the great blood-vessels suspends completely the relative functions; thus producing the stupor and insensibility of the apoplectic paroxysm.

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* Not only are different parts of the brain liable to destructive disease, without a corresponding derangement of the functions of the organ, but the whole tissue exhibits occasional varieties in its appearance. Sometimes the mass is unusually dense and firm; sometimes it is watery and soft. Both these conditions have been observed in persons who have shewn no symptom of insanity; and many insane individuals, on the contrary, exhibit no cognizable tokens of deranged structure in the brain, when examined after death. The same observations apply to the other viscera, which all admit of a certain extent of degeneration, before their function is suspended or deranged. In our total ignorance of the primary movements of life, it is difficult to separate the essential from the accidental.

It has been a favourite speculation among physiologists to determine a peculiar spot in the cerebral organization, in which they might place the seat of perception. The *sensorium* or *centrum commune* of thought, τὸ πρῶτον αἰσθητήριον, is a metaphysical notion, derived from that of individuality, which, though necessarily adopted for expressing our ideas, has no foundation in physiological observation. In the reptiles and some of the inferior animals, it has already been stated that perception is performed in the spinal marrow after decollation. To add, however, to the absurdity of a specific *centrum commune*, the last term of sensation and the first of volition, it has been further considered as the seat of the soul. Thus, as usual, have the ideas of matter and of spirit been confounded; and the inconceivable essence of immortality converted into a mere tangible being; a sort of internal man, the *double* of the organized animal, and (as Aretæus observes of the womb) ὁκοῖον τι ζῶον ἐν ζώῳ. The opinion of Descartes, which enthroned the soul on the pineal gland, is now best known by the ridicule which the wits of the last age have attached to it. The internal cavities of the cerebral organ, termed its *ventricles*, have likewise been considered as the seats of perception; and (which is still more extraordinary) a serous exhalation, found in a fluid form in the ventricles of the dead subject, but existing during life as a mere vapour, has been also fixed upon as the *ipsissimum sentiens* of the brain, the point of communication between the body and the soul.

Perception is the result of a primitive law of the organization, inscrutable in its nature; and, like digestion, or muscular contraction, cognizable only in its effects. It is eminently difficult for the imagination to connect the phenomena of thought with the movements of matter; and philosophers have boldly considered them as independent of it. The fact of their connection must, however, be admitted.

The organs of sense, the sole inlets to knowledge, are expressly adapted for establishing relations between the animal and the material world; and beyond that point the sphere of mental activity does not extend. There may indeed exist in *rerum natura* forms of matter, whose properties stand not in relation to our senses, and whose affections and modes of action we cannot conceive; but for every purpose of reason such substances are to man, as if they had no existence.* They can form no parts of his system of knowledge, nor can they be made to harmonize and dovetail with material agency. As far, therefore, at least, as ideas are the subjects of human contemplation, they must be regarded as changes impressed upon the substance of the brain, by the impact of bodies that are external to its tissue. To this point alone can investigation be satisfactorily conducted. Inquiries pursued beyond organization terminate only in the wildest conjectures, and the most contradictory propositions: while the reduction of intellectual action to the same laws as those which govern other organic phenomena, affords a positive and satisfactory base for moral and metaphysical investigation.†

The admission of this fact has no relation whatever with the doctrine of an immortal soul, nor with any other dogma, founded on faith, and independent of reason.* The theological soul must be clearly distinguished from the *primum mobile* of relative sensibility; in order to avoid the obvious dilemma of conferring immortality, not only on animals but on vegetables, or on the other hand of denying it to man.†

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* "Il n'existe pour nous de causes exterieurs que celles qui peuvent agir sur nos sens, et tout objet, auquel nous ne saurions appliquer nos facultés de sentir, doit être exclu de ceux de nos récherches." *Cabanis.*

See also Locke on the extent of human knowledge, § 6.

† That thought consists in movements, and is consequently obedient to the general laws of motion, is evident from the single fact that time is necessary for its accomplishment.

The relations of the different tissues to the nervous centre are regulated in accurate harmony with their respective necessities. Perception is not equally excited by the same impression, when made indifferently on any tissue; but each organ is governed by its own peculiar laws, so as to solicit the attention to those affections only which are most interesting to its own well-being. All impact, capable of disordering function, excites sensations more or less disagreeable; and as each part is liable to be injured in its own peculiar manner, it operates upon the seat of perception through the agency of distinct and peculiar causes. The intestinal canal is stimulated to painful impression, by indigestible substances; the skin, by sudden changes of temperature, and by destructive chemical and mechanical agents; ligaments, by forcible distention; the lungs by impure air, &c. &c. But as, in addition to the perception of injury, the preservation of the animal requires that there should exist also a power of avoiding it, the five senses establish a nearer acquaintance with external nature, and are thrown into action by slighter changes in its arrangements, so as to give more precise ideas of the causes of foreign agency. The notices obtained of the affections of remote bodies, through the impulses of reflected light; and by the vibrations of the air, anticipate painful impressions; and enable the animal to guard against evil, while it is yet at a distance.

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* These dogmas rest entirely upon scripture authority: and the soundest divines have refrained from mingling philosophical investigation with religious faith.—See Memoirs of B. Watson—on the locality of the soul, vol. I.

† "But here I take liberty to observe that, if your Lordship allows brutes to have sensation, it will follow either that God can and doth give to some parcels of matter a power of perception and thinking, or that all animals have immaterial, and consequently, according to your Lordship, immortal souls, as well as men; and to say that fleas and mites have immortal souls as well as men, will possibly be looked upon as going a great way to serve an hypothesis."

Locke's Letters to the Bishop of Worcester.

It is curious to observe how the most acute metaphysicians writhe under the spiritual theory.

The metaphysical proposition of "*nihil in intellectu quod non prius in sensu*," (which forms the foundation of Locke's immortal work) now universally admitted, requires a slight alteration, to accommodate it to physiological truth. Internal sensations, produced by diseased action, or occurring in the ordinary discharge of function, are the sources of some ideas; and changes in the internal condition of the viscera operate powerfully in modifying the nature of our reflections. They afford, therefore, a seeming objection to the theorem; but, with respect to the sentient organs, these viscera are external; and still more so, the stimuli by which they are excited. Without changing, therefore, the terms of the proposition, it is sufficient that they be somewhat enlarged in their application, in order to admit these sources of ideas, which ought to be considered as belonging to the class of sensations of touch.

The mechanical structure of the eye causing a picture of visible objects to impinge upon the optic nerve, has induced metaphysicians to liken the ideas to *images;* and the power of combining them has in common language been termed *imagination.* This loose metaphorical way of speaking has led to many mis-conceptions; especially to that of supposing a resemblance between the ideas and their external prototypes. It is abundantly evident that no such resemblance can exist. A shock of electricity, it has been stated, will, in passing along the course of the several nerves of sense, excite odours, tastes, visible impressions, &c. A violent blow on the eye produces the sensation of a strong flash of light. Certain derangements of the abdominal organs occasion not only more definite sensations, but long trains of reflex ideas, without any corresponding external prototypes. Of this sort must be considered the dæmon of Socrates; for the general character of that philosopher places him above the suspicion of wilful deceit. Such, also, were probably those supernatural appearances of devils, &c. &c. testified by the anchorites of early Christianity,—those at least of them which are not the pure inventions of more worldly-minded and designing men. The enthusiastic exaltation of mind, which engages the hermit to quit society, and to impose upon himself severe privations, together with the rigour of his fasts and discipline, renders him a very fit subject for " thick coming fancies" and mental hallucinations, whose specific character is still more immediately decided by the subjects of his habitual contemplation. But to return :—

In the several ideas, thus excited, there manifestly cannot exist a resemblance between the causes and their effects : nor could the notion have arisen among metaphysicians, had their contemplation of the subject been accompanied by physiological observation. For when it is clearly perceived that an idea is merely a movement effected in the cerebral tissue, the possibility of a resemblance between it and the objects of external nature is instantly dissipated; and it becomes evident that such a congruity as shall determine at all times the same cerebral movement, on the presence of the same exciting cause, is amply sufficient for the purposes of perception.

For the production of sensation it is not enough that the peculiar stimulus of an organ of sense be brought into contact with its appropriate nerve; the attention must also be free from pre-occupation by other stimuli. For the cerebral substance is not susceptible of an indefinite number of coincident sensorial movements. Thus it often happens that sensible impressions are made on the organs, and become the parents of associated ideas, without any distinct consciousness of their presence in the intellect.

Impressions of sense admit of two modifications; in one of which the mind seems to receive them passively; while in the other it appears to exert itself, and, as it were, to go in search of its ideas. When an object possesses such a relation to the percipient as to excite an interest, it becomes the subject of a closer scrutiny. The animal does not then *see* and *hear* merely, but *looks*, *listens*, *examines*. The nature of this process seems to be mistaken. The eye, the ear, the fingers, &c. are instruments adapted to specific purposes; and, like all other instruments, may be applied in a manner more or less perfectly fitted to the discharge of their offices. When external objects excite but a slight interest, they do not afford motives for any great accuracy in the employment of these organs; but when the passions operate, and give importance to an object, the muscles attached to the organs of sense are thrown into such a state as experience has taught to conduce most perfectly to the exercise of their function. In gazing upon a distant object, the eye-ball is steadily fixed, in order that the same parts of the retina may be kept for a continuance in correspondence with the same points in the subject of contemplation. The brows likewise are contracted to exclude the rays of light, which interfere with those proceeding from the object, and which obscure its image. In listening, the ear in like manner is turned to the side from which the sound proceeds; and in examining by the touch, care is taken to give, with the utmost exactness, that precise degree of pressure which causes the most delicate reactions of the nervous structure.

In the active employment of the taste and smell, the impressions are increased in strength and duration, by voluntarily retaining the sapid matter in the mouth, and by forcible inspiration of the odorous particles through the nostrils. All these efforts tend, in their several ways, to produce a stronger stimulation of the sentient fibres, and consequently a clearer and more forcible idea in the intellect; but they afford no evidence to warrant the received belief, that the active employment of the senses is accompanied by a corresponding difference *in the mode of receiving the sensations*, arising in a distinct faculty or function of the brain itself.

The objects of sense, in exciting the organs upon which they inpinge, produce the unknown change in the cerebral tissue termed consciousness. This change includes a perception of the impression, a sense of the individuality of the percipient, and a reference of the impression to its external cause. Great pains have been taken to search for the evidence of external nature: but its existence is among the number of those facts which are connected with our organization; and of which, however, unsusceptible of proof, it is impossible to doubt. A glance into nature overthrows at once the *a priori* reasonings of metaphysicians, and shews that a conviction of the reality of ideal prototypes is an integral part of sensitive impression.* The utility of all organization depends upon this fact. Impressions might succeed each other *ad infinitum*, without producing the slightest reactions, if it were possible for the mind to doubt of the reality of their sources; for the motives of volition must cease, when the causes of sensation are known to be internal, and their supposed objects purely unreal and imaginary. The instinctive actions of animals also, which commence immediately after birth, must demonstrate an intuitive belief in external existences. For if the animal required to argue itself into the acknowledgment of a connection between its own sensations, and their external causes, life would be destroyed before it could arrive at the necessary conclusion. Lucian tells us, that the souls of the sceptic philosophers had not found their way to the fortunate islands, to join the shades of the deceased, because they had not yet made up their minds to the existence of the place, and therefore had not proceeded on their journey.* *τοὺς δὲ Ἀκαδημαϊκοὺς ἔλεγὸν, ἐθέλειν μὲν ἐλθεῖν, ἐπέχειν δ' ἔτι, καὶ διασκέπτεσθαι· μηδὲ γὰρ ἀυτὸ τοῦτο πῶς καταλαμβάνειν, ἐι καὶ νῆσος τίς τοιαύτη ἐστιν.* This would accurately describe the condition of the infant, if it did not immediately refer the sensitive impressions derived from the maternal milk, to the breast in which it is secreted, and infer the existence of the external object from that of the sensation. The Berkleian theory on this subject has been ridiculed by many wits; but the proper view of the argument is not even at this day sufficiently common among metaphysicians.

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* It is scarcely necessary to refute the idle position respecting the qualities of external matter. The same substance, we are told, may produce, under different circumstances, impressions of a different nature. It may be sweet to-day and bitter to-morrow: there is, therefore, no such quality as sweetness or bitterness in that body.* To this it should be replied, that there is a permanent relation between the chemical constitution, or physical arrangement of particular bodies, and the sentient fibres of definite organizations, in virtue of which, they are capable of exciting certain ideas. The terms bitter and sweet, rough and smooth, as applied to the sentient beings, refer to the corresponding sensations; and when predicated of the foreign substance, they likewise designate the combination of causes, which produce its specific agency. It is therefore just to say, that sugar is sweet, or that it possesses that constitution which usually excites the idea of sweetness, when applied to the human palate. Change that constitution, or change, on the other hand, the organization, and the effect equally ceases.

* Sir W. Drummond's Academic Questions.

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* Luciani Verarum Historiarum, l. ii.

That the consciousness of external prototypes is independent of reality, and arises from a certain configuration of the organs themselves, appears from the phenomena of delirium. Of this truth the memorable hallucination of Pascal is a striking example. This philosophic and acutely logical genius, could not convince himself that a gulf was not ever yawning close by his side,—an idea which arose in consequence of an hypochondriacal affection that excited cerebral movements, analogous to those which should accompany the visible phenomena of such a chasm. In this case, experience must have taught the patient the "unreal mockery" of his imagination; yet, when alone, he could not resist the organic tendency to credit the impressions, which appeared to arise through his senses.

It may be a subject of sceptical enquiry, whether external agents produce the same effects upon the cerebral tissue of every animal; whether a ray of red light, for example, appears the same in the intellect of all beholders. To this question there can be but little hesitation in replying in the affirmative: for though the fact cannot, from the nature of things, be reduced to experiment, yet the broad principle of analogy, which deduces similarity of effect from similarity of cause, places the fact almost beyond doubt. The power of *exciting reaction*, however, which any given stimulus may possess, must necessarily vary in different individuals, and in the same individual at different times. The degree of reaction upon a given stimulus is determined by the energy of vitality in the organ to which it is applied, by the habits of the organ with respect to the stimulus in question, and by the pre-occupation of the organ by other stimuli at the time of its impact. Age, sex, temperament, diseases, education, climate, original peculiarities of structure likewise modify every individual, and determine in each a manner of thinking and acting which mark his identity. Although, therefore, for the general purposes of society, a coarse and approximating system of justice dispenses rewards and punishments with sufficient accuracy, yet, strictly and morally speaking, there exists not in the human breast a criterion for appreciating the actions of others. Each animal forms within itself a little republic, whose laws and usages are peculiar; and to condemn one man according to the affections and habits of another, is to impeach him *coram non judice*, before a tribunal to which he is not amenable.

One point must still be greatly dark,
The moving why they do it;
And just as lamely can ye mark
How far, perhaps, they rue it.*

The movements which are excited in the brain by external impressions, and which constitute ideas, occasion a change in that organ more or less permanent ; in virtue of which, they become more easily excitable for the future, agreeably to that law of organized contraction, designated by the name of *habit*. It is in this change that must be sought Locke's supposed faculty of retention. If all acquired notions existed simultaneously in the brain as (to use a favourite metaphor) in a storehouse, the poet's remark would be applicable to the meanest intellect.

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* Burns.

> ————That still the wonder grew,
> One little head contained the whole he knew.

They have manifestly, however, but a potential existence ; and the recovery of ideas may remain within the scope of possibility, although, from want of an exciting cause, those ideas may appear to have been totally forgotten.

The sensorial movements are eminently under the influence of association. Impressions, which have occurred simultaneously, or successively, which resemble, or contrast with each other, mutually act as causes for their respective re-appearances, and suggest each other in an almost endless series.

The order in which associated ideas succeed, may be varied according to different suggestions : and to this power may be traced those intellectual processes, which are usually attributed to distinct faculties. When a present impression excites a train of ideas, in the order of their original occurrence, the process is attributed to an act of memory. When the order of the train is determined by the intervention of a second idea, having many circumstances in common with the first, according to the principle of comparison, it is termed an act of judgment. When the train proceeds on the principle of exclusion, it forms abstractions; and when on a principle of combination, it is considered as invention, or genius. The determination of association, in any one of these directions, in preference to another, results from the necessity which the machine is under of reacting congruously upon the impressions it receives.

Those impressions which excite a certain degree of pleasure or pain, or which experience has associated with those affections, stimulate the cerebral system to volition; an action which influences the muscles, and determines their contractions in a definite and congruous series.

The actions thus produced may proceed immediately from the impression, and in close connection with it: they are then termed *instinctive.* They may result, also, from the associations which the impression excites, and be governed by a consciousness of the end to be produced; and then they are called *voluntary.*

Instinctive actions are immediately subservient to the preservation of life, and are prompted by sensations of pleasure or pain considerably acute. They arise, in some cases, from peculiar conditions of internal organs; and in others, from strong impressions made on the organs of sense. In the lower animals, the stomach and generative organs originate nearly all the loco-motive actions. The motives of the higher classes are more varied and numerous.

In man, and the animals most nearly resembling him, the healthy exercise of the functions is connected with an infinite variety of circumstances, over which experience gives the animal a certain control. It is therefore moved not only by the immediate impulses of appetite, but by all causes connected in their agency with its gratification; hence, avarice, ambition, and all the complicated chain of motives, which influence man in society. All causes, which tend to the healthy exercise of the organs, are necessarily considered as good; and those which tend to interrupt or derange them are as necessarily deemed evil.* This is the true and only intelligible signification of those terms, whose abuse has led to so much false morals and false philosophy. The stoics, who were influenced by a belief in the reality and *unity* of good and of evil, have fallen into the greatest errors in their idle disputes on these subjects. They were driven to the coarsest shifts, and to the most bare-faced sophistry, by their denial, that pain is an evil; and by their conclusion, that whatever is accidental, is below the consideration of humanity. As if human existence were not wholly and absolutely the subject of accident, and man were not obliged by his nature to take advantage of all the accidents of life; riches, honors, strifes, contentions, labour, the combinations we term luck and fortune, &c., &c.; and to turn them as much as possible to the multiplication of healthy and pleasurable impressions, and to the diminution of those of a contrary tendency. The qualities of good and evil do not reside essentially in any of the substances or combinations, by which man is affected, but are determined by their relations to the percipient, which are transitory. The possession of any good, which interferes with the enjoyment of one of a higher order, is an evil; and evils become good, when they stimulate to successful exertion, and to enlarge the sphere of human activity and power. There are in fact but few objects capable of influencing mankind, that operate only in a single direction; and of which it can be absolutely and abstractedly asserted, that they are good or evil; and it is on this account the more necessary to discover a standard by which their agency may be appreciated—a standard which cannot subsist in externals, but must be sought in the nature and properties of the subject, on which they act.—But to return. The impressions of pain and pleasure, when intense, become motives of action too violent to be resisted. The reactions connected with them result immediately and intuitively.

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* Omnia quæ natura aspernetur in malis esse; quæ asciscat, in bonis.—*Cicero.*

> The blood will follow where the knife is drawn;
> And sighs and groans by nature wait on pain.

Those which are remote or less violent, are capable of being balanced by counteracting causes, by anticipations, hopes, and fears. The degree and mode of reaction they excite, must, therefore, vary in every individual, and at every juncture. It seems not improbable, that, in the commencement of life, all physical impressions are attended with a sensation of pleasure, or of pain. Infants take evident delight in the exercise of their senses; and their incessant activity must find its motives in a corresponding vivacity of sensation. The law of habit will explain the indifference, with which those impressions become ultimately received, that do not contribute to a change in the organic condition.

There is, in the several organs, a principle of activity, which renders the absence of their appropriate stimuli a source of pain and uneasiness: the emotions thus excited, the appetites, desires, and passions, are among the most powerful incentives to action. Their presence not only produces, with considerable energy, determinate movements in the organs of loco-motion, but is accompanied by peculiar derangements of the organic functions, over which the will has absolutely no control.*

The connection between the mental affections, and the organs from whose influence they arise, or upon which their action especially falls, is not always very obvious. Love, jealousy, and maternal affection, are attached to the developement and activity of determinate parts, and are necessary supplements of their functions. But fear, courage, anger, sorrow, hatred, &c. produce changes of organic movement, which have no such evident foundation in utility. Joy and grief affect alike the whole nutritive actions. Fear makes the heart palpitate, drives the blood from the surface, and acts violently upon the intestinal canal. Courage, on the contrary, gives a more forcible heat to the heart, while anger throws the capillaries of the skin into strong action, and determines the circulation more exclusively towards the head. Hence rage is a very frequent occasional cause of epilepsy and apoplexy, producing phenomena, which ignorance and bigotry attribute to the particular judgments of an offended Deity.

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* Galen (De Causis Symptom.) reduces all the passions to two movements: one from the circumference to the centre; and another from the centre to the circumference. The first embraces fear, sorrow, and the debilitating passions; the other includes the opposite affection of anger, joy, &c. This notion is adopted by Dryden:

> These heats and colds still in our breasts make war;
> Agues and fevers all our passions are.
>
> *Ind. Emperor.*

There arise also in the human animal certain other movements, which, when excessive, are metaphorically termed passions. Amongst these are avarice, ambition, the love of play, &c. Such emotions, however, partake not of the true nature of passion, being totally unaccompanied by organic derangements. They consist in vitious associations of cerebral movements, which give an undue vivacity and force to particular ideas, producing reactions, incongruous with their causes, and injurious to the percipient.

The connection of the true passions, with their organic affections, impelled Bichat to consider the organs, thus influenced, as the causes of the feelings which disturb them ; a proposition which, except in as far as it applies to the appetites, is perfectly gratuitous, and is not indeed very intelligible.

The passions, once excited by an object, may become so associated with it, as to be afterwards roused by its recollection or reappearance, although the disposition or power of influencing the well-being of the percipient no longer exists in it. On this fact depends the beauty and the truth of Pope's impassioned epistle of Eloisa to Abelard.

The principle of activity, which arises from the necessity for functional action, manifests itself in the cerebral tissue by an avidity for sensation.

Even a certain degree of pain is preferable to an absolute suspension of interest.* Hence idleness is said to be the mother of mischief. But as the frequent repetition of sensations diminishes their intensity, the sources of pleasure become exhausted ; more especially when forced gratifications of sense are adopted to anticipate the functional recurrence of pleasurable action. In this case, the reproduction of faded appetites and palled desires is sought in a succession of different stimuli ; producing inconstancy in the affections, and a restless and incessant change of scene and of pursuit. The imagination, despising the present, seeks all its enjoyments in the combinations of the morrow; and life slips away unenjoyed from an inordinate and inconsiderate effort to increase enjoyment. On this principle also must be explained those extravagant and fictitious passions which debase the moral being, and form the wretched substitutes for nature's purer and more vivid delights.†

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* "C'est pour s'arracher à l'ennui, qu'au risque de recevoir des impressions trop fortes, et par consequence disagréables, que les hommes recherchent avec le plus grand empressement tout ce qui peut les remuer fortement," &c.

Helvetius sur l'Esprit, v. ii. p. 46, chap. 5.

† It is thus that, according to Helvetius, a coquette forms the best mistress for an idle and exhausted man. "La plus forte passion de la coquetterie, est d'être adorée: que faire à cette effet ? Toujours irriter les passions des hommes, sans jamais les satisfaire."

The passions founded on the wants of the organization, are appeased by their gratification; and their indulgence, if not excessive, tends to health, vigour and happiness. But the factitious passions of envy, ambition, gaming, &c. increase in intensity with their gratification; and by their unrelenting tyranny, tend necessarily and inevitably to disappointment and misery.

Among the causes which modify reaction should be mentioned those which act through the social affections. The human animal is born with the strongest instinctive tendencies to be moved through the accidents and sufferings of the species.

> Naturæ imperio gemimus, quum funus adultæ
> Virginis obcurrit, vel terra clauditur infans,
> Et minor igne rogi. Quis enim bonus et face dignus,
> Arcana, qualem Cereris vult esse sacerdos,
> *Ulla aliena sibi credat mala.*

The poet is not, however, to be followed in his sequent conclusion, that this law distinguishes man from the inferior animals; for in those evils which come within their comprehension and can be expressed by intelligible signs, the gregarious animals sympathize extensively with each other: of which fact a multitude of instances will occur to the attentive student of nature. The tendency of reason is, on the contrary, too frequently opposed to the natural sympathies. The simple and uncultivated man, provided his feelings are not stifled, and his heart narrowed by an excessive difficulty in procuring the first wants of existence, and by a consequent life of penury and distress, is open to all the kindlier feelings of nature, and sympathizes readily with the stranger. It is enough that he sees misery to attempt its relief, even at the hazard of life. While the creature of high wrought civilization, whose multiplied necesssities and artificial passions oblige him to reason at every step, and to calculate every action, is, too frequently, self-centred, cold, and indifferent, and he extracts the materials of individual gratification, even from the failure of friends,* the misfortunes of his country, or the grave of his longest and most tried connections. With such men disinterestedness is folly, and patriotism a pretence. " Dans l'état actuel de la société (says Chamfort), l'homme me paroit plus corrompu par sa raison, que par ses passions. Les passions (j'entends ici celles qui appartiennent à l'homme primatif) ont conservé dans l'ordre social, le peu de la nature qu'on y retrouve encore.† But in the most corrupt members of society it seldom happens that every social feeling is stifled, and that no motives are influential which extend beyond mere individual enjoyment. The welfare of the species is a necessary object to an animal destined to live in society; and the noblest and the best dispositions obey most implicitly its calls, as the strongest and most developed animals of the herd place themselves in the front of the battle when attacked by an enemy.*

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* Dans l'adversité de nos meilleurs amis, nous trouvons souvent quelque chose qui ne nous déplait pas.

Maximes de Rochefaucault.

† Œuvres de Champfort, Maximes et Reflections.

The theory of external agency and of organic reaction is a long disputed subject among metaphysicians. The grand problem of moral evil, and of rewards and punishments, has given a bias to their reasonings, which can only be rectified by an appeal to physiological fact—an appeal, against which pride and the love of hypothesis equally militate.

The phenomena of relative sensibility, like those of nutritive action, consist essentially in the application of stimuli, the sensation of their presence and the consequent reaction of the contractile tissues ; and these phenomena succeed each other in the same order, and according to the same law, in both cases. Yet while a strict necessity is acknowledged to preside over organic life; metaphysicians persist in believing that the laws of material agency exert no influence over the relative functions; that there is no definite connection between the stimulus and the reaction ; that the relations of cause and effect are superseded, or rather that two or more effects can indifferently proceed from the same cause.

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* The natural tendency of reason is to extend our regards from the individual to the species; for true philosophy is always benevolent. But reason continually turned aside by false systems and established prejudices, is rarely exercised upon premises of perfect soundness. The mass of mankind are so much occupied in providing their daily subsistence, that they have not time to look around them; and they are obliged to reason upon the few scanty facts which fall within their sphere of observation. As the grounds of selfish inferences are of the most frequent occurrence, the man of the world forms to himself a system of personality the more complete as society is more complicated; and it is worthy of remark, that France, the country where, before the Revolution, social existence was most polished and wire-drawn, gave birth at once to the class of egoïsts *par excellence*, and to the denomination by which they are distinguished.

To arrive at this conclusion, it has been necessary to adopt two distinct principles of motion in the animal system, which are distinguished by the appellations of instinct and of reason. The first of these principles is allowed to operate necessarily, because the simplicity, and consequently the greater apparent regularity of its agency, preclude, the possibility of mistake. In the more complex nature of volitions, determined by reason, a wider field is open to dispute; and upon this ground the fantastic edifice of free will has been erected, and fortified, and intrenched, with all the subtlety and sophistry of polemical metaphysics.

In the actions termed instinctive, the connection between cause and effect is immediate. As soon as the new-born animal feels the impressions of the atmosphere, it performs the process of inspiration ; and those species that are born with a fully developed muscular system are immediately capable of walking. In like manner every species of animal, when attacked, puts itself in that posture for defence or flight, which its organization requires, without reflection and without foresight. These movements, essentially and immediately connected with the preservation of the animal, proceed from a single, powerful, and unopposed stimulus. There is but one congruous mode of action, and if that did not follow from the organization itself, the species must ultimately perish.

In deliberate volitions, attended with a consciousness of end, the process is not so simple. The action to be produced, not being of such immediate importance in the economy, may be influenced by other causes present in the intellect, or to speak more physiologically, by other stimuli acting on the cerebral tissue. The means of annoyance and of pleasure, which nature affords independently of the immediate preservation of the animal, are numerous and varied ; and memory or imagination may produce them under numerous combinations to oppose or modify an existing impression. When two or more ideas of nearly equal force, are thus opposed to each other, an immediate reaction would not be congruous to the great end of all action. It is necessary that each motive should be clearly and distinctly perceived, and its relative value felt; and for this purpose hesitation is compulsory. During the interval thus created, the several ideas, associated with each motive pass through the mind, and the reaction is ultimately determined by that motive which, with all its associations, makes the strongest impulse on the sensorium.*

According to Locke, the hesitation which ensues, when the animal is simultaneously acted upon by contending motives, is voluntary; and in this supposed power of arresting action, he places the free agency of man; but hesitation is a necessary result, motived by the opposition of ideas. If one idea gets strong possession of the intellect, if it very powerfully stimulates the cerebral organ to reaction, it inevitably supersedes the others, and prevents them from being clearly perceived and attended to; and hesitation immediately ceasing, the individual can no longer refrain from action.

The more closely and accurately the facts are examined, the less physiological ground of distinction will be found between the reaction of instinct and that of reason.† Many actions proceed indifferently from one or the other of these causes. The first efforts at sucking are automatic; but the process is afterwards performed by a deliberate act of volition, with a preconceived knowledge of the end to be produced. The first efforts at playing on a musical instrument are deliberate; the movements of the practised musician follow instinctively and without thought, being closely associated with the visible impressions of the notes in the music book before him.

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* Nous croyons délibérer, lorsque nous avons, par exemple, à choisir entre deux plaisirs, à peu près égaux, et presque en équilibre; cependant l'on ne fait alors que prendre pour délibération la lenteur, avec laquelle, entre deux poids, à peu près égaux, le plus pesant emport un des bassins de la balance."

Helvetius.

† Condillac, convinced of this verity, considered instinctive actions as the results of rapid and ill developed reasonings. Is not reason, on the contrary, a more developed and complex instinct?

In any given situation in which a man may be placed, there may be two or more possibilities of action; but it does not follow that the individual can act in either of these ways indifferently. This may be predicated of *man in general;* but it is a gross abuse of language to assert that the *same man* has the power of choosing the consequences of his situation. The man of instinctive bravery will fight, the coward will necessarily fly. The moral man will be influenced by his notions of propriety, while the man who is a stranger to such motives can no more will in obedience to them, and in contradiction to his other propensities, than a stomach, full to repletion, can will itself to be hungry. Peculiar circumstances, of extraordinary influence, may induce such deviations from ordinary conduct, *but the relation between cause and effect remains unchangeably the same.*

In those actions which are influenced by the suggestions of reason, and are therefore believed to be under the control of the will, every step of the process, every intervening idea is necessitated by that which precedes; and the determination is as strictly proportionate to the nature of the stimuli, and of the percipient, as in the simpler cases of instinct. Nor is this proposition doubted in those instances in which one influential idea bears down and overpowers the rest. Self-defence is an admissible plea for murder, not as a justification of crime; for morality teaches that it is better to suffer, than to commit injury; but because it is an acknowledged law of the organization, that such movements are irresistible. Upon the same principle, extreme hunger absolves a thief from the penal consequences of his overact.

By a similar train of reasoning, the strength of temptation is allowed in abatement of moral censure, in those cases even, in which the law, for the preservation of society, is obliged to strike; a mode of thinking, which could not be justified, if there really existed a power of resistance, independent of motive.

The power, which any motive may abstractedly possess, depends upon circumstances over which the will has no control. There are many cases, in which impressions bear no relation whatever in strength to their influence upon the well-being of the individual. The passions, when irritated by opposition, produce the most dangerous and painful effects, which fall no less upon the nutritive than upon the relative systems. Long trains of ideas are irresistibly introduced, which lead to the most irregular actions; and they disorder not only the moral conduct, but the physical constitution.* The passion of love, to take an instance, is proverbial for the violence of its consequences:

> In amore hæc omnia insunt vitia, injuriæ
> Suspiciones, inimicitiæ, induciæ,
> Bellum, pax rursum; *incerta hæc si tu postules*
> *Ratione certa facere, nihilo plus agas,*
> *Quam si des operam ut cum ratione insanias.*

These evils, these agitations and afflictions, which embitter life, forbid pleasure, and shut out all other interests of existence, cannot voluntarily be encountered; nor can they be shaken off at pleasure by their victim. They arise out of a peculiar state of the constitution. They cannot exist in him, who is physically disqualified for the passion; neither can they be controlled in him, with whom the perfection of nature operates as an incessant impulse.

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* Λέπτον δ'
Ἀυτίκα χρῶ πυρ ὑποδεδρόμακεν,
Οππάτεσσιν δ' ἐδὲν' ὀρημι, βομβεῦ-
σιν δ' ἀκοάι μοι·
Καδδ' ἰδρὼς ψύχροις χέεται, τρόμος δὲ
Πᾶσαν ἀγρεῖ, χλωροτέρα δὲ ποίας
Ἐμμὶ· τεθνάκην δ' ὀλίγω' πιδεῦσα,
Φαίνομαι ἄπνους.

These derangements depend upon alterations in the balance of circulation and the other nutritive functions; and are necessary and incontrollable results of the mental affection.

That the passions are not controllable by a bare act of volition, is evident from their imperious influence over the nutritive system. The most practised hypocrite is unequal to repress the automatic movements. which a predominant and agitating passion naturally excites. The rising blush of shame, the pallid hue of apprehension, the unbidden tear of grief, the illuminated eye of joy, spurn the dictation of the will, and betray the inward secrets of the heart, to the most careless observer. The murderer does not willingly turn pale at the aspect of his mangled victim; the perjurer does not voluntarily hesitate and sicken, when confronted in open court: so, on the other hand, the most eloquent advocate will fail to excite these animal movements in those whom habit or natural insensibility has exempted from the feelings to which they belong. There can scarcely, therefore, remain a doubt, that the moral reactions of the individual are likewise necessitated and independent of volition.

The natural bounds to the influence of the passions are set in their mutual balance; a balance, which, in the well organized animal, is proportioned to the necessities of the moment. In such an animal, the predominance of each emotion is strictly proportionate to the excitement: rage is elicited only by real offence; and the amorous feelings do not survive the cause for which they are implanted. But the movements, in which the passions consist, being subject to the law of habit, they become more easily excitable by frequent repetition; and as each temperament has its predominant passions, most men are born victims of some feelings, to which they are compelled to obey.

As the reactions produced by these movements are seldom proportionate to their causes, the passions, when excessive, become truly diseases; and society is interested in their repression, by the presentation of contravailing motives.

The teachers of morality, though professing to believe the passions under the influence of the individual, have always acted as if acquainted with their real nature. They have either attacked them by diminishing the physical force of the man, by a vegetable diet and by the loss of blood (as in the system called *minutio monachi*) or they have set up one passion against the other. Avarice and worldly mindedness are attacked by vivid descriptions of another and a better world; and the sensual passions, by vanity, by fear, and by enthusiasm.

Governments for the most part employ fear as the great controller of other movements: and parents, in general, call into play every passion in its turn, as a counterpoise to the one that happens to be predominant or troublesome at the moment. Perhaps one of the most fatal sources of exaggerated passions lies in the indiscreet use, which the preceptors of youth thus make of them, in their wretched systems of education.

When habits of action are once formed, they are rarely broken down by the suggestions of such motives, as arise under the influence of other passions. A violent sensible impression is much more influential. Thus an unlucky blow, inflicted during a paroxysm of rage, is more likely to subdue a tendency to that passion, than the best arguments which reason can suggest.

The artificial necessities and desires of social life moderate to a very great extent the natural passions, by the multiplicity of motives they suggest of contrary tendencies. A man must be very choleric to shew signs of anger to the patron on whom he is dependent. Savages are much less capable of dissimulation than Europeans; not because their passions are stronger, but because they have not the same motives for counteracting them.

As life advances, the passions chase each other away; because they are many of them incompatibles.* These alterations are usually attributed to the strong exercise of volition; whereas the will follows passively in their train, and obeys successively the tyrant of the hour.

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* Il y a dans le cœur humain une génération perpetuelle de passions; en sorte que la ruine de l'une est presque toujours l'établissement d'une autre.

Rochefoucault.

The want of an internal, active principle, capable of correcting the exaggerated impressions resulting from passion, is felt in all the institutes of society. When temptation to crime increases, the legislatures of Europe know no better expedient for its repression, than the exaggeration of punishments. But in the best conducted education, more is gained by an artful avoidance of the occasional causes of passion, than by a direct conflict with their prevailing tendencies.

The general and most successful efforts that are made in this latter direction, consist in inoculating (if we may so speak) the subject with the factitious passions of emulation, ambition, avarice, the love of honour, and fanaticism. Under the influence of these guides, the instructor sometimes succeeds admirably, in making what the world calls a good sort of man:—

> Not quite a madman if a pasty fell,
> And much too wise to walk into a well.

Such people abound in the world; they will neither cut a purse nor a throat, (except according to established etiquette,) nor do they in general fall into any vices that are wantonly outrageous: but such men may, in reality, be thoroughly worthless and degraded; selfish, plodding, and mercenary; and just so far stoics, that "*si fractus* *illabatur orbis*"—if the whole world should fall to pieces they would stand unmoved; provided the insulated circle of their own petty interests remained without injury amidst the ruin.

How passively the will obeys that motive which is, in fact, the strongest, appears from the variety of results which follow the same outward contingencies, under different modifications of the same individual. If the "conscience hang about the neck of the heart;" if the dread of danger, or of penal consequences, afford a stronger excitement than the temptation to crime, the most unprincipled villain will abstain from its commission. But give to that man an intoxicating fluid, (which, by quickening the circulation, shall increase his courage, and at the same time hurry on his ideas, and obscure his powers of reflection,) and the deed will be infallibly committed.*

It happens occasionally that a sudden revolution takes place in the habits of thought and action, which have hitherto characterized an individual. From prudent and moral, he becomes dissipated and violent; or, after a life of irregularity and excess, he suddenly abstains from criminal indulgences. These cases afford no exceptions to the general rule. The decay of one passion, the evolution of another, a sudden loss, an unexpected disappointment, a fit of sickness, or a paroxysm of ennui altering the balance of internal forces, will, one or the other, most frequently be found to explain the mystery. It is in these moments of crisis more particularly, that sudden changes are effected in opinions; that fanaticism seizes its victim, and substitutes its own inordinate excitements, for others less dangerous both to society and to the individual.* Without some such extraordinary causes, few persons in advanced life make decided alterations in their opinions and actions; for as the limbs by use acquire peculiar gesticulations, and become dexterous in the performance of particular actions, so the mind is moulded to an idiosyncrasy of perceptions, of comprehensions, judgment, and propensity; and thus acquires a definite mode of volition, from which it rarely escapes.

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* It might, methinks, somewhat abate the insolence of human pride to consider, that it is but increasing or diminishing the velocity of certain fluids in the animal machine, to elate the soul with the gayest hopes, or sink her into the deepest despair; to depress the hero into a coward, or advance the coward into a hero.—*Fitzosborn's Letters,* L. viii.

That the passions are never annihilated, but by the disappearance of their physical causes, and that they are not under the control of the will, is yet more clearly evinced in the phenomena of repentance. In acts of a criminal character, the possession of the object is commonly followed by a repentance of the deed. In these cases, nothing is changed but the state of the individual, with respect to the dominant passion. The passion satisfied, it suffers a temporary remission of its tyranny, and the desires of the individual are altered; he *repents*, that is, he thinks over again, and the sum total of his impressions, with respect to the act in question, is totally changed.

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* Women are more especially open to the impulses of fanatic devotion at that period of life, when, their personal beauty decaying, they are deserted by the men, and those passions, which have made up the sum of their former existence, are mortified or repressed. Hence the truth of the somewhat too jocose remark, that heaven has ever "les beaux restes du beau sexe."

Peculiar modifications of passion not only determine the ideas, which association shall present to reflection, but influence the impressions of the very organs of sense. An individual under the influence of inordinate vanity is insensible to the shouts of laughter which convulse an assembly at his expense. The external signs which distinguish applause from the triumphant laugh of ridicule, are apparent to all but their object; he alone sees nothing, and hears nothing, but the suggestions of the paramount orgasm; he exults while his friends are covered with confusion and shame.*

If a numerous party traverse a country, the same visible objects will present themselves to all. The same cities, woods, rivers, plains, mountains,

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* This is the physical basis of the facts which have originated the proverbial aphorism, that " beauty is in the lover's eye."

&c. will pass across the retina of every individual; yet each person will have seen them in a different and peculiar way. The soldier will have before his eyes strong positions, plains, defiles and ravines; the farmer will have seen the crops, the improveable and the barren soil; the painter will be impressed with lights, shades, picturesque groupings, and landscapes; and the epicure will be struck exclusively with the produce of the earth, as available to luxury and the pleasures of the table. Not only the permanent habits of cerebral motion, but transitory combinations change the character of impressions. The same objects strike very differently upon the imagination, in solitude and silence, and when they are presented amidst lights, music, and cheerful company. The image of death in cloisters and in cemeteries is depressing and melancholy; yet the Egyptians rendered it a visible means of exciting hilarity, when circulated among the guests at the festive board.* If the movements above described be incontrollable; if it be impossible that the painter, the farmer, the soldier, the anchorite, and the feasting Egyptian, should see with the same eyes, it is absurd to suppose that in the same circumstances they can will the same actions.*

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* In the most splendid festivals of this nation, Herodotus informs us, that the servants bore round the table the wooden image of a dead man, elegantly carved and finished; at the same time admonishing the company to make the most of time.

Ἐς τοῦτον ὁρέων, πῖνε τὲ καὶ τέρπευ· ἔσεαι γὰρ αποθάνων τοιοῦτος.—*Euterpe.*

In order that the reason should hold that sort of control over the passions, which is meant by free will, it should be enabled to recall, at pleasure, every train of ideas which can bear upon a subject, and give to each its proper force of impression; a condition evidently impossible. When the stomach labours under a diseased excitement, the animal cannot, by the mere will, direct its sympathetic associations, so as to determine an head-ache preferably to a fit of the gout; so likewise it cannot compel one train of associated ideas to start preferably to others, in order to determine a peculiar moral reaction. Conscious of the inefficacy of the will in this instance, and aware that they cannot "with an argument reset" either a pulse or an emotion, individuals too frequently attack the relative sensibility, through the organic functions; and employ wine, spirits, and opium, to banish sorrow, stifle remorse, or inflame courage. This would be a useless, no less than a dangerous practice, if the mind could at pleasure govern its own images, and induce, at discretion, determinate modes of action.

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* Il me semble que nous ne jugeons jamais des choses que par un retour secret, que nous faisons sur nous même . . . . On a dit fort bien, que si les triangles faisoient un dieu, ils lui donneroient trois cotés.—*Lettres Persannes.*

Ἵπποι μὲν θ' ἵπποισι βόες δὲ τὲ βȣ͂σιν ὅμοιας,
Καὶ κὲ θέων ἰδέας ἔγραφον καὶ σῶματ' ἐποιȣν
Τοιαῦθ' ὁιον πὲρ κ'αῦτοι δέμας ἐιχον ὅμοιον.

Xenophanes Colophonius apud Clem. Alexand. Strom. iv. p. 256.

The phenomena of disease exhibit this truth in a still clearer point of view. In the disease called hypòchondriasis, an unknown but peculiar sympathy, between the brain and abdominal viscera, gives origin to some fantastic and unfounded idea, which, mixing with the ordinary reflections, disturbs their connection, and produces incongruous actions. Where this idea is not concerned, the patient reasons accurately; he can transact business, compose poetry, analyze a problem. Thus if the subject of his hallucination be, that his body is made of glass (a very common idea with hypochondriacs), he will conclude (justly, from such premises), that motion is attended with the danger of fracturing vital parts; and no argument will induce him to change his position. He cannot divest himself of this morbid impression; and its diseased force vanquishes all other ideas, and subdues them to itself. Between the condition of this person, and that of an individual labouring under a ruling passion, there seems to be no assignable difference, except in a slight degree, in the force of the hallucination.

However unwilling mankind have shewn themselves to admit the conclusion in their theories, their conduct accords in most cases with the doctrine of moral necessity. Education is given to children, because such evidently rare combinations of external circumstance, are required to enable a man to educate himself. It is commenced in infancy, from a conviction of the superior strength of the earliest formed habits; which inevitably give a permanent colour to the remainder of life. To inculcate religious dogmas, before the mind can comprehend them, would be a manifest absurdity, if it were intended that each individual should judge for himself, and believe only upon examination and conviction; but this is not the design of the parent. Firmly convinced himself of the verity of his creed, and aware that man is altogether the creature of circumstance, his object is to prejudice the infant in its favour; and to fix its component ideas so firmly in the mind, as to enable them to resist any possible combinations of mature reflection; and thus the obedience of the child is ordinarily secured to that order of things which the parent approves. To this principle may be traced those national peculiarities of thought and action, which are so difficultly shaken off; and which operate so fatally to prevent improvement. Every nation, collectively speaking, is blindly bigoted to its own religion, its own code of laws, morals, and customs; and continues, from generation to generation, preserving an idiosyncrasy of mind, not less remarkable than that of form and feature. It is, therefore, amongst the most inconceivable paradoxes, that so much intolerance should exist in all ages and climes, amongst persons pretending to be raised above the vulgar, and to be emancipated from prejudice; since the opinions of man are so evidently, of all his possessions, those which he is the least entitled to call his own.

If, from the permanent features of national character, we turn to the points of difference, which distinguish the same people, at different epochs, they likewise will prove illustrative of the general proposition. In the great revolution, which the last two centuries have produced, every successive change has taken place by succeeding generations. A new impulse was given to man by the invention of printing, which has progressively carried forward the species to novel modes of thinking and of acting. But each generation has stood still at the precise point at which opinion remained at the period of its education; and the novelties which genius has elicited, have been almost exclusively embraced by the next coming race, who have received them with a less pre-occupied mind. Thus, at the present moment, the very old men in France are royalists; the middle-aged class affords the greatest number of constitutionalists; and the boys are more generally devoted to the imperial government, and to military enthusiasm.

The very existence of social institutions, of codes of law and morality, is founded upon the invariable and necessary connection of cause and effect in the human mind. If the intellect were not the function of a machine, governed by invariable laws, it would be clearly impossible to form general rules for influencing moral conduct. It is from the necessary proportion between motive and action, that credit exists between man and man; and that previous character is the foundation of confidence. In one word, the uniformity which history exhibits in the conduct of man in all ages and climes, is alone compatible with the system of necessity. Under any other law of action, experience would afford no insight into futurity, and the accumulated wisdom of ages would be without connection, and void of utility.

To return, however, to physiological fact: either the brain is totally useless in all that relates to mind, or the mental phenomena are governed by the laws of organized action: but organic action follows necessarily from the condition of the organ, and from the nature and quantity of the stimulus. The stomach cannot choose to digest or not to digest; nor refuse to obey stimulations, because they are unwholesome or destructive. In the same manner the brain reacts of necessity upon the causes which operate upon it, whether they are or are not calculated to promote happiness, or conduce to the permanence of the individual. Beyond the mere fact, the physiologist is not bound to extend his researches, or to examine the inferences which may be drawn from it by inquirers of another description. But this observation may be permitted him, that the doctrine of necessity is neither depressing, anti-social, nor impious. In its influence on human laws and institutions, it must coincide with man's best interests; inasmuch as it tends to a stricter proportion between crime and punishment; at the same time that it opens a wider door to pity and forgiveness. In the affections it can make little change, neither tending to impair the bonds of gratitude and obligation, nor rendering the individual careless of human happiness. For the social and patriotic feelings are not dependent upon abstract principles, but spring at once from organic impulse; and love and hatred are instinctively excited by inanimate as well as rational objects.* When these natural affections are suppressed by the predominance of artificial passions, men may seek arguments to justify their new tendencies; but the heart is never corrupted by the operations of the intellect. The love of what is beneficial is as necessary as the appetites which support life; and it cannot be influenced by dogmas of any character, save only when propagated by fanaticism. Lastly, as to all that respects the dispensations of Providence in rewards and punishments, the doctrine of necessity and that of free will equally leave the world where they find it; involved in doubts and difficulties, which the intellect cannot solve; and of which each individual thinks according to his own peculiar measure of grace and of faith.

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* Love and hatred are instinctive movements referring uniformly to qualities that affect our well-being, and perfectly independent of moral considerations. "On rit," says Helvetius, "de la colère et des coups d'un enfant; il n'en paroit souvent que plus joli; mais on s'irrite contre l'homme fort; ses coups blessent; on le traite de brutal."

The necessary connection, which it has been the object of the preceding pages to establish, reigns over the several modes of cerebral action which are considered as faculties; and governs the memory, the imagination, and the judgment, no less than the will.

Whenever a sensitive impression of a certain strength has been made on the cerebral organ, a permanent change takes place in its mobility; so that, when the impression is repeated, it will affect the individual in a different way from that which followed its first application. Besides the consciousness of an external object, to which the impression may be referred, there is likewise a recognition of its former existence. It is uncertain how far this may depend upon a specific law of the organization, or result from that of association. The probability is, however, in favour of the last supposition; for in the act of dreaming, (in which former impressions are repeated, without the presence of their prototypes,) the recognition of their former existence does not always take place.

The distinction between ideas proceeding from real objects, and those suggested by fancy, is also wholly made by the medium of association. Every impression, excited by an external object, becomes associated with many others; and when the idea is a second time introduced, as part of a chain, either of remembered or imagined ideas, the disagreement of its own associations, with the actual sensitive impressions of the moment, seems to distinguish it from the suggestions of the senses; and to produce the conviction, that its corresponding object is absent. In dreams, where no such comparison can be made between sensitive impressions, and the suggestions of association, (because the senses are then inaccessible to stimuli,) the ideas, which constitute the dream, are mistaken for realities.

Few persons will be disposed to doubt that the recognition of former impressions is totally beyond the control of the will; and follows necessarily upon the second application of a stimulus, when the first has been sufficiently strong, to effect the requisite change in the cerebral organ. If a person behold a flower for the first time, he cannot will to recollect it; neither can he refuse to recognize it upon a second acquaintance. The recollection forms as necessary a part of the impression, as the acknowledgment of its external cause. But, in the case of a recollected idea, the will is generally supposed to interfere in regulating the order of the phenomena; a belief which does not seem founded in observation.

In order that an idea may be remembered, it is absolutely necessary that it should be connected by its associations with some idea actually present in the intellect. It is impossible to will the presence of notions totally absent from the contemplation.

Ideas, to which the attention has been riveted, become more readily excitable, in virtue both of their original strength and of the greater number of associations which they will necessarily have formed.

Ideas fix the attention in proportion to the strength of their impression, their connection with the passions, and the disengagement of the mind at the moment of their entrance. When the intellect is forcibly pre-occupied by a train of ideas, external impressions are scarcely perceived. It is thus enthusiasm blinds its votaries to the calculations of common prudence. With the mind thus engaged, a savage smiles amidst torments, a Mutius Scævola inflicts upon himself the severest sufferings, and the martyrs to truth and to falsehood hurry with equal alacrity, and equal obstinacy, to solicit the notice even of unwilling persecutors.

The strength of an idea, or its power of commanding attention, depends upon its apparent connection with painful or pleasurable sensation, either immediate or consequential. A person who, never having seen or heard of a lion, beholds it for the first time, in the act of tearing its prey, will more certainly remember that animal at a distant period than if he had seen it in a less imposing attitude.

Another source of forcible impressions lies in the strengh of their associated notions. Trifles, observed in critical and interesting moments, become permanent in the intellect. Hence the tendency to date from remarkable epochs; women from the birth of their children; citizens from the years of their several civic honours, &c. &c.

Impressions are greatly strengthened when they follow in a series quadrating with some canon, of which the mind is possessed; each idea being suggested by that which precedes it. The words and the air of a song mutually tend to fix each other in the memory.

Independently of these properties in the impressions, the mind has no power over the attention; this condition, therefore, rapidly subsides by the failure of stimulating force in the ideas; for the mental stimuli, like the corporeal, abate in the intensity of action when applied for a considerable time. When therefore the mind has been forcibly engaged with an ungrateful subject, by the predominance of some strong interest, that interest gradually loses its force, until the balance turns in favour of the repulsive motives; and then other ideas involuntarily rush upon the intellect, by the same law that throws into action the antagonists of those muscles which have been over exerted by a continuous effort.

Attention is not then a faculty, but a peculiar condition of the cerebral organ, induced by the strength of impressions, and it cannot subsist simultaneously with respect to more than one train of ideas.

The attention is rarely, if ever, fixed upon an insulated impression; but is occupied with many ideas proceeding in trains. If a rose, for example, be the object of contemplation, it excites ideas of the disposition of its parts, its colours, and odours. There may likewise be associated with it ideas of the garden where it grew, of the time of day, the state of the weather under which it was plucked, of the person who was present, and of the subject of conversation which passed at the time. In this manner ideas, which are of familiar occurrence, become connected in endless series.

In the phenomena of memory, an idea excited, either immediately or remotely by a sensitive impression, calls up another which has a certain relation to existing interests, but whose component parts are not distinctly present in the mind. The pain or uneasiness occasioned by this obscurity becomes a motive for repeating other ideas connected with the subject, in order, by their associations, to arrive at the notion which is wanted. In this case, if A be the original idea, its associations will not proceed in the natural order of their reception, A B C D E F, &c. but in another series, governed by their connection with the idea X, which is required. Thus, if the idea present be that of the person of an individual, and the idea sought be his name, the natural associations might be his size, figure, coat, the place and time where he was seen ; but the influence of the idea which is sought would perhaps preferably suggest the visual impressions of his hand writing, which may lead the mind to the first letter of his signature, and thus, after several trials, to the name itself.

The phenomena of memory are purely organic, whether the idea present itself spontaneously, or be solicited with a consciousness of end. In the latter case, the interest attached to the required notion gives fixity to the ideas already present. The cerebral motions in which they consist are successively repeated, till some association leading immediately to the required idea be awakened, or till fatigue ensues, when the interest ceasing, other ideas intrude, and the intellect passes, without attaining its object, to another occupation.

The impossibility or possibility of recovering an idea, depends upon the imperfection or perfection of the chain of associations which connects it with the notions actually present in the mind. Some of the component parts of the required idea must therefore be present in the intellect. The efforts at recollection consist in repetitions of associated chains, motived by the interest of the lost idea, and as the mind cannot will the recollection of an idea totally absent, so it cannot, by an act of volition, continue the investigation when the interest has subsided.

In efforts at recollection, the ideas sometimes proceed in a logical and syllogistic series, so that the steps of the process may be retraced; more frequently the organic movements are performed too rapidly for consciousness, and the idea flashes at once on the mind as if without connection. It often happens also that, after a protracted but ineffectual effort, the idea arises spontaneously, and interferes with the new trains upon which the mind is then occupied. It should seem that in this instance, the cerebral tissue has been thrown into a state of orgasm by the previous effort, and repeats at intervals the movements on which it has been exercised, independently of the will, and thus accidentally introduces the required idea.

From these facts it is abundantly evident, that memory is not a distinct faculty, inherent in a peculiar organ or subdivision of the brain, but the result of associate movements of the cerebral tissue. These movements take place with the greatest facility at that time of life when the mobility of the system is the greatest, and they are difficultly excited when age has rendered all the organized tissues solid, and has impeded their motions. Like all other organic movements, they are strengthened by habit.

If the memory were a distinct faculty, all images would equally disappear when that faculty decays. But early impressions, fixed by their original intensity, and frequent repetition, remain indelible, and the more recent ideas alone fade from their inherent feebleness.

> The memory of recent things devoured,
> Even in the acting; on the shattered brain,
> Though the stale registers of youth remain.*

If the memory were a distinct faculty, it would necessarily follow likewise that the earliest possible impressions would be recollected, and the child remember all that had passed, at least from the hour of its birth. But memory depending upon association, it is manifestly impossible that many facts should be remembered, before the possession of language affords the instruments of a numerous and varied connection between the separate ideas.

The interest of the animal requires that all ideas, connected with any subject of investigation, should be equally excitable, in order that its actions should correspond with the true nature of the conjuncture; but this is by no means consonant to fact. Habitual trains of ideas, by their physical preponderance, intrude, in preference to others of more importance, and produce corresponding habits of action. The objects of external nature that excite them thus exercise an influence over the individual, prejudicial alike to his judgment and happiness. Fielding has made a humorous application of this law, in carrying Squire Western from the pursuit of his daughter, after the fox-hounds, which crossed him in his journey to London.

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* Churchill.

In the same manner, trains of ideas connected with the functional action of predominant organs acquire a disproportionate force from the orgasm of the part. Esau, when subdued by hunger, was thus governed by ideas suggested by the stomach, to the exclusion of all others. The notions of future ease, comfort, and happiness, less forcible than the suggestions of appetite, were excluded from the attention. Those who are strangers to the vicissitudes of savage life, and who take their meals, however homely, at stated intervals, will not comprehend the condition of mind which induced the unfortunate hunter to sell his birth-right for a mess of pottage ; but the more familiar case, in which not only birth-right, but morals, rank, and reputation are exchanged at the command of passion, and a world is sacrificed for a Cleopatra, will illustrate it to the dullest apprehensions.

The multiplicity of permanent impressions are unfavourable to memory, by exciting too numerous associations. Hence it becomes a point of prudence to know what ideas should be strengthened by repetitions; and to neglect such links of association as are no longer useful in the education of the mind. Thus, when languages have become familiar, the recurrence of the rules of grammar, by which they were acquired, would interfere with the business of composition.

Various artificial methods have been imagined for improving the memory. Among the ancients, before the invention of written characters, metrical arrangement was, with this view, made the vehicle of public instruction; and the bard was at once the law-giver, the priest, and the physician of the people. Early in the history of the arts, traces may be discovered of arbitrary systems of arrangement adopted by orators in their harangues, for the preservation of order and concatenation of argument. These consisted chiefly in the assignment of the heads of discourse to certain visible objects in the place of assembly; a practice from which has descended to us the familiar phrase of *common placing*. Different attempts have been made to extend this system, and to give it the form and substance of a science. But experience has abundantly proved, that for the purposes of permanent use, such contrivances are totally inadequate; and in every respect inferior to that which nature has employed for the same purpose. The natural ground work of memory lies in the importance and interest of the facts to be retained, the clearness of the original impressions, and their arrangement in the series of their several connections. A good method of teaching is the best help to memory, by presenting facts in their proper order, and tracing, with a steady hand, their discrepancies and agreements. A memory thus founded is not only a machine readily thrown into action, but in its application necessarily leads to new and unexpected combinations: while a recollection founded upon arbitrary associations, (however artfully put together,) can produce nothing beyond the naked facts in a state of unprofitable and uninteresting insulation. In addition to this inconvenience, arbitrary associations become liable to be mistaken for real connections; and the natural and artificial memory, thus mixed together, must produce the most monstrous and extravagant absurdities.*

The suggestions which constitute memory, like those of sensitive impressions, are not equally excitable at all times. Violent exercise, strong passions, whatever hurries forward the ideas with an excessive rapidity, enfeebles their associations. The gentle stimulation of the circulating system, which is procured by a moderate use of wine, quickens the memory, in common with the other intellectual movements. Epilepsy, apoplexy, and such diseases as injure the structure of the brain, produce sudden and extraordinary changes in the connections of ideas. The memory of some ideas may be totally obliterated by a fit of apoplexy; while others remain fixed and permanent in the intellect. Learned persons, under these circumstances, have been known to lose the use of their vernacular dialect, and yet retain a perfect recollection of the Latin and Greek; which they have spoken, on recovery from the fit, to the astonishment of their servants and attendants.* Sometimes the memory fails with respect to particular objects: persons are forgotten, or the names of things, in the most common use, escape the recollection. During delirium the increased mobility of the cerebral tissue revives associations which had long been deemed lost. Recollections of the early childhood are renewed; and the subjects of hallucination are often those which for years had ceased to occupy the mind.

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* Thus, in Von Feinagle's mnemonical system the idea of Julius Cæsar is recalled by the association of a *Jew*. It would be scarcely possible for a child, to whom these notions are thus presented, to avoid confounding the Roman dictator with a vender of old clothes.

The ideas which external objects are capable of exciting, are not all adequate to determine muscular actions. They do not always develope the relations subsisting between the object and the percipient; other associate movements, therefore, intervene between sensation and volition. If the deficiency of intelligence lies in the paucity of the ideas, the animal is impelled to a new and more careful application of the object to his organs of sense: *he experiments* upon it. If, on the other hand, the relations of the ideas to the necessities of the organization are not sufficiently clear, he examines and compares them with the suggestions of experience: *he reasons*. The nature of this process remains to be examined.

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* Bishop Watson quotes a singular instance of this sort in the person of his father, who was afflicted with palsy:—"I have heard him," says the bishop, "ask twenty times in a day, what is the name of the lad that is at college, (my elder brother,) and yet he was able to repeat, without a blunder, hundreds of lines out of classic authors."—*Bishop Watson's Life.*

The art of reasoning depends, in a great measure, upon the power of associating objects and other impressions with arbitrary signs. It is, therefore, more exquisitely performed by the gregarious animals than the solitary species; and infinitely more so among men; with whom the organs of speech have become the instruments of the most extensive combinations of symbology.

The first efforts of man in the use of signs consists in giving names to the visible and tangible objects by which he is surrounded. These objects, however, are each of them capable of addressing themselves to more than one sense, and of making simultaneously many impressions; and the next step in the formation of language, is to give names to such of these separate sensations as require discrimination; as well as to the properties in which they believe them to originate.*

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* Great inaccuracy of idea has arisen from the poverty of language in this last particular. The same name being commonly affixed to the idea, and to the cause by which it is pro-

Objects and ideas, having among themselves certain points of agreement, are susceptible, when considered under these points of view, of forming groups, representable by a single sign. Thus ideal existences are formed, which receive names, and rise one above another in increasing complexity. The several affections which objects are capable of exciting, require likewise to be named: and as very many objects are capable of exciting the same ideas and affections, the mind, referring this capability to a common cause, assigns to it also a denomination.

Without, however, further tracing the progress of language, it is sufficient to observe, that the operations of mind are more immediately performed by means of the signs, than by the objects themselves. All objects that have received names, however complex their character, are regarded as individuals; and the nature of the several component cerebral movements they originate, does not become the subject of consciousness, except under the pressure of particular necessities.

In the cursory attention which objects excite, when not intimately connected with the prevailing interest, the intellect takes but little account of each individual movement; but when the at-

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duced, the two have been much confounded. Hence the ridiculous quibble, that there is no heat in fire, no sweetness in sugar: as if the causes of these sensations did not inhere in the objects which excite them.

tention is forcibly arrested, all the component ideas are repeated with a clearness and precision that renders each distinguishable in its turn, and capable of renewing its specific associations. The crude notion of the object thus becomes converted into the separate impressions of colour, form, substance, polish, hardness,* &c. &c.; and the interest the object has excited, may thus, perhaps, be transferred to some one of its properties. Thus, in the absence of a knife, the mind referring to the properties, which enable it to cut, might, by association, be led to other substances, in which those properties reside; and find a ready resource in a fragment of flint, or piece of glass. In this operation, the cerebral movements which constitute the complex idea are analyzed; the separate notions belonging to each property of the subject do not occur (as at their original reception) simultaneously and confusedly; but are repeated in series governed by the other ideas with which they are brought into relation in the process of reasoning. The facility with which this process is effected, depends entirely upon the language; for the separate impressions, unless associated with a name, are too fugacious and imperfect to be recalled at pleasure, or to be clearly distinguished from the rest of the complex movement. This process of analysis is adopted equally with respect to ideas and to their external prototypes. The substance we term nitre, known originally as a natural production, excited no other notions than those of its sensible properties, colour, taste, hardness, and the property of increasing the ignition of combustible bodies, &c. &c. Experiment afterwards succeeded in discovering its component parts, nitric acid and potash; and these again have been reduced to the three elements potasium, nitrogen, and oxygen. In a similar manner our ideas of virtue are decomposed into benevolence, industry, honesty, &c. &c.; and these again reduced by analysis to the preservation of the individual, and the well-being of the species.

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* Condillac.

The facility which language affords of analyzing an idea, serves also for the purpose of synthesis. In analysis, the separate portions of the same complex notion are successively and clearly excited. In synthesis individual impressions of different complex notions suggest each other, by their common connection with some third idea; so as to produce new species, which are purely creatures of reason. A painter, for example, commences by a deliberate observation of the complex objects which a view of nature presents. The landscape is analyzed into houses, water, sky, foliage; and these again are reduced to lines and colours, light and shade, perspective, groupings, contrasts, effects, &c. From this examination, clear and precise ideas are formed of an object, which originally excited but a confused combination of cerebral movements. From the stock of ideas thus acquired, the artist is enabled to draw materials, which he combines according to the suggestions of his present intentions; forming ideal landscapes, water pieces, forest scenery, streets, &c. &c. in compliance with the varying demands of his several employers: and these ideal prototypes direct his muscular movements in realizing and embodying them upon the canvass.

In this process, which is that of all inventors, no new movement is excited in the brain; but the order and connection of existing impressions is changed, by their associations with a common notion, with which they have become newly connected.

The objects of sensitive impressions, especially those which address the eye and the ear, recur so perpetually, that they become united in series infinitely various; and thus are capable of mutually exciting each other, in endless combinations. Thus in sleep, the same primitive impression, (one, for example, arising from indigestion,) when it has excited a visual idea, may proceed through that idea to suggest an infinite variety of horrible images producing a different dream, in each successive sleep: and in reverie, in which the ideas successively suggest each other, uncontrolled by a consciousness of end, the associations are so various, that it is impossible to fortel what direction the thoughts may take. In those synthetical processes, which form parts of human speculations, the succession of ideas is determined by the leading notion of end or object; with which the others have a definite connection. Whatever associations may arise incongruous with this governing idea, are rejected, and become unproductive. In general, however, the interest of the subject gives so much strength to the ideas connected with it, that they exclude all others, and prevent them from intruding, until a certain degree of weariness commences.

The varying susceptibility of individuals, for these sympathetic associations, depends upon the relative force of their organization. In some persons the impressions of sense never excite clear ideas; their movements, both cerebral and muscular, are loosely connected with their corresponding sensations; and they are capable of few efforts, except those which are of immediate importance to life, and are most nearly instinctive. But where this physical defect does not exist, we find the ideas in one person suggest themselves most readily in the order of their natural occurrence; in others, according to the relations of cause and effect, &c. &c.; in a third, according to the suggestions of picturesque beauty, or moral fitness; and thus these persons have respectively a leaning to memory, mathematical combination, mechanic contrivance, or invention in the fine arts. These differences seem to depend, in part upon habit, and partly upon the predominance of those ideas which are connected with prevailing organic tendencies. Thus those who are not used to employ their minds, will have their ideas most forcibly associated in the natural order of their original reception ; they will have good memories.*

Those who inhabit picturesque countries, and those whose organization impels them to live much in the open air, will probably be struck with the sensible images of nature, and delight to describe them either as poets or painters. Strong and turbulent passions will beget a disposition for those combinations, which most directly influence society; while a mathematical or mechanical genius belongs to a passive and subdued organization. This influence of the general structure upon the intellect cannot be doubted. There are few persons, in whom the sexual orgasm has not, at some time, provoked a disposition for poetry and imaginative composition; however averse their general disposition may be from such occupations.†

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* This condition is chiefly observable in women; and among pastoral and semi-civilized nations, where society is but little complicated.

† These general principles require to be taken with great allowance. Man is not a machine, moved by a single spring; and when education and society act upon him, it is by no means

When circumstances excite a tendency to invention in individuals, unqualified for the process; if they succeed in obtaining any result, it is by the recurrence of ideas in the order of their original suggestion. The memory is taxed, instead of the imagination, and thus flat parodies upon established models are mistaken for orginal inventions. This error occasionally misleads even the brightest geniuses—"Faded ideas float in the fancy, like half forgotten dreams; and imagination in its fullest enjoyments, becomes suspicious of its offspring, and doubts whether it has created, or adopted."* To this cause must be attributed the multitude of unmeaning centos in poetry and music, of revivals of obsolete combinations in mechanics, and of common-places and truisms in essays and the graver literary productions, the constant and inevitable characteristics of presumptuous mediocrity. Such plagiarisms, whether voluntary or involuntary, equally prove the dependance of memory and of invention upon the common principle of association; the ease with which the two processes may be mistaken fully evincing the identity of their mechanism.

The movements, which are excited by the separate sensitive impressions are necessarily involved in a vast variety of complex combinations,

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easy to trace each insulated fact to its particular and immediate cause.

* Sheridan.

by which their individual force is diminished, and, as it were, concealed. The influence of language largely contributes to the same effect: for when names have once been attached to complex ideas, they are used like counters in arithmetic; their real value, in the ordinary processes of thought, remaining long unnoticed. But when ideas, remotely connected with the passions, appetites, and necessities of organization, are made the motives to action, it becomes important to ascertain the meaning of such terms, and to discover whether all the ideas belonging to them have the same relations to the subject in consideration; or whether they may not imply more or less than at first sight is supposed.

In a state of nature, the art of reasoning would be confined within very narrow limits. The few ideas of the savage turn almost exclusively upon subjects of primary importance, and their value is at once *felt* from their nearness in interest. But the invention of language, by multiplying ideas, has embarrassed the intellect with its own riches. The introduction of complex terms, more especially has rendered the frequent examination of the ideas an object of pressing necessity; for in the various combinations, into which these terms enter, they do not always represent the same precise ideas; but sometimes one, and sometimes another of their component notions takes the lead in the intellect; the mind, however, deceived by the identity of the sign, is not always conscious of the variation in the thing signified.

Another frequent source of error lies in the terms which stand for classes of ideas, and which cannot equally represent all the several individuals with the same accuracy: and when two complex terms include many common ideas, they are apt to be mutually mistaken, and to be considered as synonymous. Amongst these, and other similar involutions of ideas, it becomes not unfrequently a most difficult task to extricate them from the labyrinth of words; and to assign them that order and connection which belongs to their prototypes in nature; or to determine their relations to other ideas, according to the truth.

These difficulties become still more serious, in the communication of ideas between man and man. The most familiar terms do not represent the same ideas in different intellects; and the mistakes, which separated the builders of Babel, are of daily occurrence, in the intercourse of society. A common observer, unaccustomed to the care and use of a horse, would, for example, attach to that term only a few vague ideas of the form, habits and services of the animal it represents. A jockey entertains a much more extensive and accurate assemblage of notions, concerning its points, perfections and powers; all which he attaches to the term in question. The painter, ignorant perhaps on this head, may have much more precise ideas of the form and beauty of the animal, and the anatomist will possess notions of internal structure, with which mankind in general are wholly unacquainted. If the signs of visible objects convey such different impressions to the intellect, it is not difficult to conceive the greater openings to mistake, which environ those terms, that represent remote, arbitrary, and ideal combinations: nor does the difficulty rest even here: for mankind are still further led astray, by the perversity of those who govern opinion; who have found an interest in associating in the intellect ideas the most remote and discordant, in order to subjugate the world, and to hold society in bondage to false principles and imaginary existences.*

A short experience is sufficient to teach the animal, that ideas, thus confusedly and falsely associated, afford motives, which, far from leading to the preservation of existence, tend directly to its disturbance and dissolution. The feeling of uneasiness which arises, when the nature and connection of notions tending to action are not clearly perceived, gives birth to a new train of cerebral actions, during which volition is suspended. Those complex ideas, whose bearing upon the subject is not immediately intelligible, become translated to new signs, in order more accurately to ascertain their value; or they are compared with other ideas, and their mutual relations examined; while association recalls similar conjunctures that have passed, that they may afford indications for anticipating the consequences of future action. It is not till these, and other similar processes, have presented all the known relations of the contingency to the intellect, and satisfied the mind as to the tendency of the impulses, that a volition is formed, and the motives followed by their proportionate contractions. The movements, which thus intervene, between external stimulation and the consequent volition, arise immediately out of the organization, and are no less necessary results of the circumstances, than those which are deemed instinctive. In instinctive efforts there exists but one congruous mode of action; the motive is single, and unbalanced; but in cases of deliberation, the motives are various, and act in contrary directions. In each instance, therefore, the phenomena are proper to the circumstances; and action or pause follow proportionately to their respective causes.

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* Among these *entes rationis*, or rather *delirationis*, are Divine right, infallibility, the *jus non scriptum*, and virtual representation of England, *cum multis aliis*, the gods of idolatry of the passing hour.

In early life, before experience has suggested ideas of consequences and of caution, mankind are obliged to act precipitately upon the first confused notions they received from without; but when ideas of danger and of difficulty become firmly fixed in the mind, they associate themselves with every impression, and form in themselves a motive to oppose to all others; and thus break down the immediate connection between sensation and volition.

When the tendencies of an impulse do not immediately arise in the intellect, from the idea by which it is suggested, the sensation of doubt and difficulty, which ensues, exalts the vivacity of those ideas, and new associations, of a more remote character, ensue. The discrepancies and agreements of the contending motives with the interests of the individual, become more clearly felt, and their relative value being thus ascertained, the intellect is said to have performed an act of judgment. In this process, no new movements are excited in the organ, but the ideas, present in the intellect, are successively repeated; till a distinct consciousness is obtained of each, and of its connection with the conjuncture under investigation. The simple sensitive motions are thus merely released from some associations, and reunited in others, by the instrumentality of language; by which the relations of the two terms of the proposition are more precisely ascertained.

Most frequently the terms by which two ideas are represented, do not suggest all the notions requisite for this comparison; and it becomes necessary to compare them with some third notion present in the intellect, in order to awaken the dormant association by which they are connected. Thus in the proposition, " Is Peter the natural subject of the king ?"—the two terms, Peter, and king, may not suggest an analytic association of the corresponding ideas sufficiently precise to determine the question. But when the term subject is analyzed, and they are mutually compared with its several component parts; that is, when the complex ideas, Peter, subject, and king, are successively repeated, and the component simple ideas intimately felt, a new train of associations commences, in which the notions of the origin and history of Peter take the lead. In this way are generated three propositions :

All persons born within the king's dominions are his subjects.
Peter was born within the king's dominions.
Peter is the king's subject.

By the developement of the ideas involved in the term subject, the ideas of birth, &c. attached to Peter, and which were not suggested by the repetition of his name, are elicited ; and as the relation of Peter to the king is contained in these ideas, that which was at first obscure becomes instantly evident.

By a similar process, when two motives excite to opposite volitions, and their respective value is not perceptible, at an intuitive glance, the uneasy sensation of doubt induces a synthetical process, in which the dictates of experience are combined and applied to the case at issue. If the action A should be performed, experience may suggest a positive result of X, containing a personal advantage that may be represented by 5, and a disadvantage equal to 2. On the other hand, if the action B ensue, experience foretels the consequence Y, involving an advantage of 2, and a disadvantage of 5. All these ideas were involved in the notions forming the impulses to A and to B; but they were not separately excitable except through the associations springing out of the hypothesis X and Y, and their subsequent analysis and comparison with each other. Until, therefore, these several cerebral movements took place, the balance between the opposing motives could not be adjusted so as to determine a volition; and they were necessary links in the chain connecting sensation with action.

In the few cases in which the ideas are intimately connected with especial functions, the reasoning processes are conducted independently of language; the impressions being strong enough to excite all the necessary associations. But the very limited extent to which the operation can be so carried, without the assistance of this instrument, is alone perceptible in the animal tribes, whose reasonings, as exhibited in their actions, though wonderfully accurate, are confined to the simplest, clearest, and most frequently repeated impressions.

The extension of reason in man is therefore more justly attributable to the perfection of the human organ of speech, and to the strength of his social sympathies, than to the mere developement of the cerebral organ. This proposition becomes at once manifest by the close connection which subsists between the reasoning powers of particular nations, and the perfection of their dialects.* In those nations which speak a highly polished language, very ordinary abilities suffice for the production of detailed and elaborate investigations; whereas among a people of rude speech, the brightest genius and the happiest combinations of circumstance scarcely suffice for arriving at simple and easy deductions. The influence of language on intellect is still further marked in the peculiar direction it gives to national talent. The Italian language, which abounds in harmony, and falls almost spontaneously into verse, has forcibly determined the genius of Italy to poetic composition. In a similar manner, the plastic flexibility of the Greek tongue carried the nation which spoke it irresistibly to dialectic subtlety; and it impresses even in the present day acuteness and brilliancy of character upon a people, whom every other moral cause conspires to brutalize and enfeeble.* For though, in the first instance, the intellectual necessities of every nation give peculiar character to its language, yet that character once formed, it influences to the end of time the genius of the subsequent generations.

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* The clown and the philosopher have the same organization; but they differ in the extent of their vocabulary.

The operation of reason falling thus principally on language, and affecting only the arrangement of ideas, it has no power to control or modify the force of primitive impressions. If two opposing passions contend for the possession of the will, reason, by developing the ideas, must, on the contrary, give strength to that passion which is already dominant, and hurry the individual in the direction of his ruling propensity. The motives which oppose the master passion are but feebly felt, while those which coincide with it act with disproportionate force. Hence reason, which, by opposing one tendency to another, is so potent against occasional caprices, is totally unequal to make permanent changes in the character. Upon this truth depends the force of the trite aphorism, that philosophy renders a man firm on the subject of the past and the future, but feeble in all that respects the present. "*Un cœur faible*," as Voltaire has justly observed, "*peut subsister avec un esprit fort, car on peut penser fortement, et agir faiblement.*" The intellect can appreciate the relations of things to each other, and to human nature in general, but their impressions on the individual are *felt and not understood.* There exists within, a leaning, a bias of the organization, which strikes the balance between conflicting impulses, not according to general principles, but in agreement with its own peculiar disposition; and thus a very wise discussion frequently terminates in the worst possible resolution.

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* In this point, and in the exalted notions of virtue and of liberty entertained by the Greek writers, depends the value of the language as a branch of education. The study of Greek has had a decided influence on the English literature, and thence upon the language and people.

This secret is fully possessed by dramatic authors in all ages. The great theatrical struggle between love and duty, which forms the basis of tragedy, is preserved through four acts, by incessant reasonings on the relations and consequences of each mode of action; but in the fifth act love is always triumphant. That intimate acquaintance with the human heart, which constitutes so large a part of dramatic genius, leads the tragic poet inevitably to this conclusion. In postponing love to any other motive, the hero is at once convicted, either of constitutional coldness destructive of interest, or of subservience to some other passion less dramatic in its nature. He becomes either whining and insignificant, or he ceases to be a lover, in order to become a courtier, a statesman, or a general. An instinctive feeling in the author and in the audience revolts from the possible residence of a cool, calculating prudence, in a bosom firmly possessed by a genuine passion.

This independence of the affections on reason forms the physiological basis of the fact, that too much research in style, too much expence of wit, is destructive of warmth in works of imagination. " *La recherche d'esprit c'est l'obstacle le plus insupportable à la puissance d'émouvoir.** There is no road to the heart through the head; the imagination may be excited by *concetti*, or the ear flattered by harmonious diction; but these agents produce no reaction of the organization. On the contrary, simplicity and even rudeness of expression, by conveying an idea of an hurried emotion, may please, in defiance of offended judgment and violated taste.

For conducting the reasoning process, a certain degree of distinctness is necessary in the cerebral movements; each impression requires such a permanence as is sufficient that cognizance may be taken of its several constituent parts. In the delirium of fever, of insanity, and of intoxication, the increased excitability of the brain prevents this fixation of the ideas. The suggestions of association take place too rapidly for clear perception; impression follows impression, and idea succeeds to idea, without allowing their mutual relations to govern the order of their succession. A strong and painful impression of light will thus induce the ideas of fire, of hell, of battle, of violence, and other causes of suffering, without any reference to their other more immediate connections.

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* Madame De Stael.

In early life the vivacity of the sensitive impressions, and the sensibility of the living tissues to stimulation, produce, in a lower degree, similar effects. The youth, anxious to enjoy, has little capability of reflection; while the mobility of his frame hurries on the reaction of volition before the reasoning process can take place. In old age, on the contrary, there is an inaptitude to change, which gives increased pertinacity to the ideas. New impressions are difficultly and imperfectly received, while old and habitual notions dwell upon the intellect; and thus a physical cause is added to the moral incitements to caution and distrust, which result from experience. It is needless to add that peculiarity of temperament may carry the instability of childhood through life, or induce a premature fixity and unlovely coldness in the season of youth.

To recapitulate the facts dispersed through the preceding pages:—The animal has no power of choosing the impressions it shall receive, or what associations those impressions shall excite. The senses being awake, are modified peremptorily by the impulses to which they are exposed, and the previous character of the intellect. The series in which associations shall proceed depends upon the relative strength of the several ideas, and their connection with the leading idea, which interests the individual. Combination, analysis, and ratiocination cannot, therefore, take place independantly of motive. The strength of an idea depends upon the force of its impression, which arises out of the perfection of the sensitive and perceptive functions, the strength of the stimulus, its relations to the natural or artificial passions, and to the orgasm of particular viscera;—in one word, in the nearness of its connection with the instinct of self-preservation. This preservation being the end which connects the relative with the nutritive functions, the consciousness of utility, object, and consequence, becomes intimately connected with the inscrutable something which is termed perception: and in proportion as the connection between external objects and the percipient is loose, the impressions and ideas they excite lose the power of influencing the cerebral organ with that strength and permanence which constitute attention.

The animal has no internal power of altering the force of its organization: it has no dominion over external objects, to regulate the force of their impression: neither is it capable of modifying the functional balance of the viscera, whose developement and orgasm regulate the pleasurable or painful impetus of peculiar impressions. The ideas which flow from impressions commenced in these viscera, (independant of external excitement,) are wholly organic, and both by moralists and jurists are confessedly exempted from moral or penal consequence.

Imagination, attention, volition, analysis, invention, judgment, &c. are not separate faculties resident in appropriate organs; but the result of definite associate movements, necessitated by the impulses, and governed by consciousness. They cannot, therefore, otherwise influence muscular reaction than according to the nature of the external stimuli applied to the organization and to the peculiar condition of that organization at the moment of their application.

It follows, therefore, that the cerebral organ is not capable of commencing those movements which constitute ideas by a spontaneous action, independent of motive;* and consequently that it has no inherent power of determining muscular movements unconnected with an external cause. In one word, it is a material organ, like all other animal viscera, and is obedient to the same necessities.

The brain being confessedly the organ of thought, various attempts have been made to ascertain the proportions which subsist between the intellectual capacity of different species, and the developement of their cerebral tissue. It is, however, abundantly evident that the single datum of the organization of the brain, is not sufficient for determining, *a priori*, the quantum of mind. It has been already stated that the functions of this viscus are materially influenced by the possibility of symbolical expression, and by the tendency to communicate ideas through signs to other individuals. The intelligence of the several species is still further affected by the developement of their organs of sense. For as the senses are the *primum mobile* of cerebral action, it is evident that, whether the brain be a well, or an ill-constructed machine, it would be equally unserviceable, unless the organs of sense also had a sufficient degree of perfection for calling it into functional exercise.

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* Under great vascular excitement, the cerebral organ, like other tissues, may be carried to such a degree of mobility as to repeat habitual motions without congruous external causes. But exclusively of this being a diseased phenomenon, it is to be remembered that the motive force resides in the stimuli, acting on the nutritive functions. Such movements are not, therefore, in any sense spontaneous.

In estimating the intellectual powers of animals, the suggestions of pride, and of the carnivorous propensity, have rendered mankind unwilling to admit their dependance on the same causes as those which produce the human intellect: and though the foundations of human anatomy were originally laid in the dissection of brutes, yet the obvious conclusion of similarity of functions from similarity of structure, has been in all ages studiously avoided, or artfully evaded.

The same impenetrable difficulty of moral evil, which, in so many other particulars, has impeded the march of philosophy, has here also operated to drive the most acute reasoners into palpable absurdities. Among the most extraordinary of these must be placed the self-contradicted hypothesis, that man alone is capable of sensation; and that the other animated species are mere combinations of machinery; maintained in action by a perpetual miracle; and exhibiting the outward signs of sensation, for the sole purpose of nurturing the compassionate feelings of mankind towards each other. This error, however seemingly absurd, is founded upon the most commonly received notions on the subject, when pushed to their extreme consequences; and of the many persons who would ridicule the notions of Malbranche and of Kirwan,* there are few who would not deny that animals are capable of reason, or are in any degree conscious of the ends which are to ensue from their actions.

That animals feel, we believe on the same evidence, which evinces the sensibility of our own species; the testimony, namely, of external signs. That they have memory and imagination is abundantly proved:* and many of their actions leave but little doubt as to their exercising a judgment upon those ideas, which are clearly impressed upon their intellects.

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* Mr. Kirwan, the late celebrated chemist and philosopher of Ireland, is said to have maintained this extraordinary doctrine in despair of otherwise reconciling the phenomena of the moral world to his ideas of the Creator. A melancholy instance of the danger of applying our reasoning powers, however energetic, to questions totally abstracted from the evidence of the senses.

But if their expressions of feeling and their actions bear a general resemblance to those of man, the substance of their cerebral tissue is perfectly alike. The organs of the several species, differing only as to their developement and mechanical arrangements. The organs of sense, likewise, bear a general analogy in all the animal species; the nature of their impressions must therefore be generally alike; and the cerebral movements they excite must consequently be similar; since the same tissues uniformly act in the same way on the application of similar stimuli.

From these considerations there can scarcely remain a doubt that the differences observable in the intellectual capacities of healthy animals, lie in the number and clearness of their impressions, rather than in the reflex movements which they excite in the cerebral system.

Of all the organs of sense the touch is that by which the most numerous and varied impressions are received, and which affords the most extensive knowledge of the properties of external nature. The mental capacity of animals is accordingly found to vary in a very near proportion to the greater or less developement of this organ.* Hoofed animals, in which the nerves usually appropriated to the touch, are inclosed in a casing of horn, are *cæteris paribus*, more dull and obtuse, than the species whose toes are divided, and covered with a thinner cuticle. Those animals, also, which have collar bones, derive considerable intellectual advantage from the facility with which they can apply their feet to objects, and thus obtain more accurate ideas of their tangible properties. The elephant possesses the sense of touch in high perfection; and though its brain is very small in proportion to the bulk of its whole body, the animal is infinitely more acute and intelligent than those species to which it is, in general structure, the most nearly allied.

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* The dreaming of dogs furnishes a familiar instance of this verity.

Carnivorous animals derive very clear ideas from the organ of smell, which is largely developed to enable them to pursue their prey. A dog in following his master by the scent, will, on arriving at the junction of two roads, take the second without examination, if the first does not afford the requisite indications; thus acting from a combination of ideas, amounting almost to a perfect syllogism.

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* "Si la nature, au lieu de mains, et de doigts flexibles, eut terminé nos poignets par un pied de cheval, qui doute, que les hommes, sans arts, sans habitations, sans défense contre les animaux, tout occupés du soin de pourvoir à leur nourriture, et d'éviter les bêtes féroces, ne fussent encore errants dans les forêts, comme des troupeaux fugitifs?"

Helvetius de l'esprit, p. 2.

The gregarious animals, though infinitely inferior to man, in their system of symbology, communicate to each other a multitude of impressions. By these means they are enabled to educate their young, and they thus arrive at a degree of intelligence, much above that of the solitary animals; even of those, of an higher cerebral organization. The tactics of migrating birds afford an obvious example of this truth. The ingenuity and acute intelligence of the monkey tribes are referable to the same cause: and the architectural skill of the beavers must likewise rest on a similar basis; since the solitary beavers, though apparently organized like those which live in society, possess no share of this singular ingenuity.

Different species of animals, domesticated under the same roof, will likewise learn from each other, many of their peculiar habits. Cats acquire the medical use of the *ægrotis canina* from dogs, with whom its employment is an instinctive propensity; and dogs in return sometimes learn from the feline tribe to cleanse their face, by the application of the fore paw; to which their organization does not naturally lead them. The education, which gregarious animals acquire in a free condition, is liable to be lost, by the domesticated individuals. The horses of Tartary, and the wild boar, are much more intelligent than the reclaimed breeds, which are protected by man, and exempted from the cares of self-preservation.

The influence of the organs of sense on the intellect is still more plainly demonstrable in the insect tribes, whose powers of volition must be founded in perceptions, commensurate with their very extensive latitude of motion. Many of these animals use their fore legs as hands; and their antennæ constitute an organ of touch, of great apparent accuracy, and of constant application; while on the other hand, their brain consists of a very small and inconsiderable ganglion, very nearly the same as that which presides over the movements of the worms.

From these considerations, it is obvious, that little dependance can be placed upon those estimates of intellectual capacity, which are founded solely on the mensuration of the brain; though perhaps, when a due allowance for other causes has been made, the size and developement of this organ, may afford indications approximating towards the truth.

The proportion of the cranium to the face has been taken as a criterion for determining the developement of the brain; and the relative size of these parts has been sought in the facial angle; formed by the intersection of two lines, the one drawn along the floor of the nostrils, and the other passing from the convexity of the brow, over the outer margin of the sockets of the teeth. The nearer these lines approach to the formation of a right angle, the greater (it is supposed) is the proportion of the cranium to the face. According to the tables constructed on this principle, the facial angle of the European is 85°, that of the African negro only 70°, and that of the ourang outang 67°. The fallacy of the test cannot be rendered more evident, than by the disparity of these conclusions. However low the European, in his pride and avarice, may choose to estimate his African brother, there can be no doubt that the intellectual difference between the two varieties is much less than that, which separates the man and the monkey. Yet the numerical degradation, indicated by the facial angle, is in the first case, seventeen degrees, and in the second only three. The dog, the ram, the hare, and the lower species of baboons, have the same facial angle of 30°.

The celebrated physiologist, Sommering, adopted another method, whose results he imagined to quadrate more accurately with the intellectual phenomena. According to his view of the subject, the brain may be considered as a combination of two parts. " That which is immediately connected with the sensorial extremities of the nerves, which receives their impressions, and is therefore devoted to the purposes of animal existence, and that portion which may be considered as connecting the functions of the nerves with the faculties of the mind ?"—Thus divided, the brain must be considered as constituting two essentially distinct organs; that of sensation and that of reflection: and the intellect is supposed to be extensive, in proportion as the latter predominates over the former. This proposition, which is purely theoretical, is not only gratuitous, but is contradicted by all that is really known of the phenomena of mind.

A more reasonable ground of conjecture is found in the proportion which the nerves of sense bear to those of volition; of which a rough estimate may be formed from the size of the *foramen magnum*, (or great orifice, through which the brain and spinal marrow communicate,) when compared with the cranium. The size of the nerves of volition depends upon the mass and the mobility of the muscles which they animate. If these organs be large, the relative importance of the spinal marrow is increased; and it becomes more capable of deriving from the cerebral centre, and disturbing its movements. It is an universal and a notorious fact, that great bodily strength and agility are rarely compatible with mental acuteness. The athletes of antiquity were uniformly ridiculed for the slowness of their intellect: repose of body, no less than freedom from passion, being deemed necessary to the successful pursuit of literary or philosophic investigations.

The relative capacity of individuals of the same species affords a subject, upon which there subsists much difference of opinion. The verity, so happily developed by Locke, of the external origin of ideas, involves, as a consequence, the proposition, that the mind at birth is a *tabula rasa*. Upon this supposition, metaphysicians have been induced to consider the brain as equally susceptible of all impressions, and to refer the different mental peculiarities observable in individuals to education, laws, customs, religion, &c. &c. &c.

Other reasoners, forcibly stricken by the marked differences observable in the intellectual characteristics of the natives of tropical and of polar regions, have hastily concluded, that climate is the proximate cause of mental idiosyncrasy. The influence of climate upon the physical frame, belongs to another place; it is sufficient at present to observe, that as it acts generally upon all the tissues, its operation upon the intellect must be regarded both as it acts directly upon the sensorial power, and indirectly through the necessities, the appetites, and the external stimulation of the other organs.

It is not, however, in examining the intellectual peculiarities of nations, that the influence of the cerebral organization can be appreciated; the differences observable between individuals placed in the same circumstances of climate, government, &c. afford more immediate and satisfactory data for the investigation. The great majority of metaphysicians, unacquainted with physiology, but intimately versed in the abstract speculations of the philosophers of Greece and the school theologians, are inclined to believe that accident and education contribute principally to the formation of intellectual temperaments, and to create the aptitude which different persons exhibit, for different pursuits.

With respect to general capacity, or genius, every physiological fact and analogy leads to the establishment of fundamental differences of organization, distinguishing the different individuals of the human race. The structural excellence and functional force of all other organs vary not only in the several temperaments, but in every individual. No two stomachs digest precisely alike, and no two hearts beat with the same force, frequency, and steadiness. It is therefore reasonable to conclude, that the cerebral tissue also admits of similar variations. The birth of ideots alone establishes this fact; nor can it be availably argued, that these persons are the victims of disease; and that our reasonings should be founded only on perfect organizations. For perfection is an abstract notion, drawn from general observations, in which the merits of each separate instance are combined in an ideal constitution, which has no real prototype in nature. There is, in all individuals, a preponderance of some viscus, which gives it a lead in the organization, and stamps a peculiarity in the harmonized action of the whole: and the tempered temperament, in which every organ is exactly balanced by the others, is a pure creature of the imagination. The assumption of perfection, in the cerebral constitution of ordinary individuals, is, therefore, a *petitio principii.*

The existence of innate differences of capacity, dependent upon organization, is rendered more probable by those peculiarities of cerebral action, which arise out of the morbid conditions of the organ. A tendency towards water in the brain is usually accompanied by a premature developement both of feeling and thought; which confers an additional interest on the individual, that aggravates the grief and disappointment attendant on his death. Certain nervous diseases develope temporary talent, which disappears again with the subsidence of the malady; a fact well known to quacks and impostors, who, as apostles of demoniacal possession, mesmerism, and similar absurdities, have exaggerated it into the demonstration of *acquirements,* never obtained by the usual route of study and learning.*

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* A French priest, arguing with an *esprit fort* of the lower class of society, insisted upon demoniacal possession, and instanced a peasant of his own acquaintance, who by means of a devil, which entered into his body, was enabled to speak Greek. The sturdy disputant only replied, that, having read Homer in the translation, he longed for such a dæmon to assist him in understanding the original. The world has lately been favoured with a specimen of the inspiration of mesmerism; and it must be confessed that it is by no means so beautiful a dream as Homer's Iliad.—See La Prima Musa Clio, translated by G. Baldwin.

Thus far, however, the question has been only considered as it respects general capacity. With respect to idiosyncrasy of talent, or its applicability to peculiar subjects, it may be observed, in the first place, that if the memory, judgment, and imagination be not distinct faculties, but, as stated in the preceding pages, modes only of association, all differences dependent upon the relative excellence of these operations must be, to a great degree, acquired, and not innate. Some variations, as has already been explained, arise in the predisposition to these different modes of action, from the intensity of sensorial power, and the general rapidity of function. The exaltation of sensibility, and the quickness of reaction peculiar to youth, are unfavourable to those comparative associations which constitute judgment; and where this peculiarity of temperament predominates through life, the individual would necessarily be better organized for a poet, than for a mathematician. Thus, though almost all educated persons have attempted poetic composition in their youth, it is never pursued in mature life but by persons of a genuine poetic temperament, and by those who are driven to practise it, invitâ Minervâ, by idleness, necessity, or the imitative propensity. A more equable and temperate flow of blood, and a less active vitality, on the other hand, are favourable to the exercise of judgment and memory.

Persons thus physically framed, are adapted to succeed in criticism, mechanic invention, mathematics, &c.; and are with difficulty lashed up to the enthusiasm necessary for poetry and the fine arts.

Some peculiarities of talent are evidently dependent upon the organization of the instruments of sense. A finely organized ear, with a moderate intellectual capacity, will produce a musical genius, whose ideas upon other subjects may be insusceptible of useful application. This combination is far from uncommon; and its character is exalted by a deficient intellectual culture, proceeding from the necessarily intense application to the musical art, and by the dissipation incidental to its practice.*

Such an organization of the eye as renders it susceptible of exciting intense pleasure, through its peculiar impressions may, in the same manner, lead to the cultivation of painting and sculpture.

From this view of the subject it may be concluded, that genius, whatever may be its calibre, is usually determined to its definite application by secondary causes. The force with which objects strike upon the senses, and thence upon the intellect, is obviously different in different individuals. And those objects, which are the most impressive, will give a decided leaning to intellectual exertion. The inherent appetency for pleasurable sensation conspires to the same end; a physical incapacity for some pursuits, forcing the individual to seek amusement in others. But above all things education, habit, the accidental concurrence of unappreciable circumstances, conspire to give an early bent to the disposition, and to favour the formation and establishment of peculiar associations. When these circumstances coincide with a happy organization of the brain, and with individual peculiarity of temperament, they produce those irresistible propensities to action which accompany the happiest exertions of human intellect. When, on the contrary, these several ingredients of excellence are opposed, capabilities lie neglected and uncultured; all the exertions being unaccompanied by pleasure, and counteracted by other incitements, they are seldom crowned with signal success.

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* Whether the peculiarity, here intended, rests in the cerebral extremity of the nerves of sense, as maintained by Gall and Spurzheim, or in their external terminations, is no part of the present inquiry. Facts are as yet wanting to decide the question.

In reviewing mankind, as divided into classes according to their intellectual endowments, it is not difficult to assign the causes which have conspired in the production of each. The born ideot, who forms the lowest degree in the intellectual scale, obviously derives his mental infirmity solely from organization. His disproportionately small brain and distorted cranium afford tangible and visible evidence of the fact. In the dolt or fool, these external characteristics subsist in a smaller degree, but are still open to observation. The mass of mankind afford less certain and precise indications of configuration to lead to corresponding peculiarities of mental condition. In them the influence of education and moral causes is more predominant. With talents of more general applicability, they are less capable of specific excellence than the individuals of higher organization, and they are therefore more dependant upon circumstance. The habitual exercise of their faculties in peculiar directions may give, however, an accuracy to their processes, which may be mistaken for genius. Individuals of but moderate talents are thus enabled to figure in the world by mere imitation, and to become learned moralists, jurists, theologians, and commentators; to go through the ceremonies of professional life with an imposing gravity and regularity, and to run round the mill-horse circle of routine with a scrupulous precision. Strong passions, by giving concentration to labour, and by fixing the mind intensely upon its objects, will develope a greater appearance of talent, and supply the place of original genius. The passion of love has a marked influence upon the intellect, and often dispels an inertness and slowness of understanding, when other motives fail to rouse the animal to volition. The poetic character of Cymon is but an exaggeration of phenomena of daily occurrence. The man of genius, who is calculated to lead forward his species in the career of improvement, is marked by a very peculiar configuration of the head, which possesses in a high degree that conformity to our instinctive feelings, which is termed *beauty*. The brain, without being disproportionate, is fully developed, expanding the cranium, forming a considerable convexity of the occiput, and elevating the forehead, so as to render the facial angle nearly a right angle. In individuals thus formed, the cerebral movements are strong, clear, and definite, and associate themselves with freedom and facility. The minutest differences of impressions are felt and acknowledged; by which the judgments become accurate, at the same time that the imaginative associations are active and prompt.

An organization, in which the associated movements are quickened by general irritability, but in which the ideas are not precise, and the judgments therefore inaccurate, is very common. The disproportion it exhibits, between its reactions and their inciting causes, constitutes eccentricity. This bastard species of talent is accompanied by capricious feelings, irregular habits, and unprofitable exertions. It forms a constitution well worthy of commiseration; a burden to itself, and often unserviceable to the community. It is almost useless here to cite as examples the names of Savage, Dermody, and

Chatterton, of Barry and Girton, the painters, and above all, of the splendid hypochondriac Jean Jaques Rousseau.

Another variety of mental condition, which has generally been acknowledged to depend upon organization, is that which is marked by an hereditary tendency to insanity. This organization is characterized by physiognomic signs; a full protuberant eye, some disproportion of shape in the cranium, to which may be added the symptoms of inordinate determination of blood to the head.

The confirmed maniac, who forms the last link in the intellectual scale, experiences a marked alteration in the visible structure and texture of the cerebral organ, which demonstrates clearly the dependance of the intellectual functions on these particulars.

Upon these grounds the universality of genius may be reasonably disputed; and the instances of encyclopædic excellence, which have in various ages been quoted, form no objection to its denial. The pretensions of a Picus Mirandola, or an admirable Creichton, have few claims on credibility. They were made in an age of comparative barbarity, when a trifling degree of attainment was sufficient to excite admiration. If similar pretensions were advanced in the present state of knowledge, they would be of no avail, but to cover the claimant with ridicule; expansion of surface having become an infallible token of a corresponding want of profundity.

In intellect, therefore, as in body, man is altogether peculiar, personal, and individual. General rules may be drawn, and abstract ideal combinations formed as a standard of comparison; but from this standard each individual, more or less, widely differs; from this perfection every one, more or less extensively, deviates—

> ——Nemo vitiis sine nascitur; optimus ille est
> Qui minimis urgetur.

In the summary view which has been offered in these pages of the vital phenomena, inquiry has stopped short at the two general facts of sensation and contraction; which, in the present state of knowledge, form the natural boundaries of physiological science, and are not improbably the *ne plus ultra* of philosophical investigation.

Ardent imaginations are not, however, content to rest satisfied with this explanation. The phenomena of organic existence, not being manifest in the constituent atoms of the masses, but depending upon arrangement and combination, they cannot be traced to the properties of the elementary particles. There is consequently room to suspect the possible intervention of an unknown element, to whose properties these inexplicable appearances in the compound may be referred.

It is not, however, from arguments thus philosophical, that the various theories of life have arisen, which in all ages have disfigured physiological science, but from a more universal error that has equally infected all general reasonings on nature.

Mankind, conscious of a power within themselves of effecting certain changes in the matter by which they are surrounded, in which the materials of their operation appear purely passive, they are almost instinctively led to attribute the great phenomena of nature, which they cannot otherwise explain, to the agency of beings, like themselves, sentient, but powerful in proportion to the more extensive sphere of their activity.

The infancy of natural science, in all nations, has been accompanied by a belief in a multitude of supernatural existences. Every wood, lake, and river has had its appropriate divinity; and the jarring of the elements was the war of the Gods.

The immediate consequence of this view of nature was the doctrine, that the visible and tangible species owe their forms and properties to the interference of such intelligences, and that the matter of which they are formed is of itself inert, motionless, and incapable. The progress of knowledge has, indeed, successively dethroned these supernatural agents, and gradually reduced the phenomena of nature within her own dominion. But the original notion of the inertness of matter had taken too firm an hold of the mind to be easily shaken; and the intelligent, impassioned principles of motion have been merely exchanged for others of a more undefined character, equally extrinsic to the masses they influence, equally inscrutable, and, it may be added, equally unintelligible.

"In rerum natura," says Cicero, borrowing from the Greek philosophy, "duo quærenda sunt; unum, quæ materia sit, ex qua res efficiatur; alterum quæ vis sit quæquidque efficiat."* The consequence of this vicious mode of considering the subject (for whatever may be the fact, matter and its movements are the sole objects in relation with the human organization,† the sole subjects of human knowledge) was the invention of still subtiler hypothetical agents, concerning which negations alone can be safely predicated, and which cannot be conceived in action without incessant contradictions and confusion of ideas.* Under this bias, existences were divided into two classes, material and spiritual; and notwithstanding the perpetual necessity for endowing the latter class of beings with all the properties and manifestations of the former notwithstanding the absence of all clear notions on the subject, and the utter incapability of attaching precise ideas to either term, as opposed to the other, mankind still continue to stickle for the distinction, and what is worse to make it a watch-word for fanaticism and persecution.†

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* De finibus.

† It is physiologically as well as philologically true, that to think is (as Tooke has asserted) to be affected by things, to be *thinged*, which literally renders the so called deponent Latin verb "*reor*." Of this obsolete form of the English verb, "me thinketh," and "me thinks," still remain to bear evidence to the truth of the position.

Under the guidance of this philosophy, a moving force has been sought to animate organic beings, distinct from and independent of their organization, which, by an abuse of language is designated by the term that is alone employed with propriety to represent the collected phenomena they exhibit. Even at the present day, "life" is too frequently taken for a substantive existence, and like the *bonum* of the schools, is—

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* Il ne peut y avoir que des vérités relatives à la manière général de sentir de la nature humaine; et la pretension de connaître l'essence même des choses est une absurdité que la plus légère attention fait apercevoir avec évidence. *Cabanis.*

† To deny the possibility of comprehending existences which have not parts and dimensions, that is to say, the possibility of understanding a contradiction *in terminis*, is most unjustly subjected to an imputation of impiety. It is not for mortals to affirm more of the Divinity than he chooses to reveal; but it is incumbent upon them to avoid such unmeaning nonsense as must necessarily lead to falsehood and absurdity. Those who are not aware of the mechanism of the human mind, would be surprised to find how nearly the proposition of a Deity without parts and dimensions, approaches to absolute Atheism. The question is not what the nature of superior existences may be, but what language can best convey to the intellect clear notions of their being and agency.

> An Animal
> Made good with stout polemic brawl.

This metaphysical distinction of matter and spirit was, however, too subtile to be attained without great labour of thought; and the *insana sapientia* of theory had made great strides before it could arrive at so perfect an abstraction. The early theogonists were clearly materialists. Homer's gods were creatures of a nature more refined than man, yet evidently subject to the affections of matter.* The physicians, in their first researches into the causes of animation, fixed likewise upon objects which, though presenting an appearance of inherent force and mobility, were still manifestly material. Πνεῦμα, Ψυχὴ, the *spiritus*, *anima*, Greek and Latin appellations for this hypothetical *ens*, are all allusive to respiration, and coincide with the Mosaic expression of "the breath of life;" the immediate and urgent necessity for this function in the higher animals, leading to the notion that the air contained, or was itself the living principle.

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* Ῥέε δ' ἄμβροτον αἷμα θεοῖο
’Ιχὼρ· οἷος πὲρ τὲ ῥέει μακάρεσσι θεοῖσιν,
’Ου γὰρ σῖτον ἴδουσ' ὐ πίνουσ' ἄιθοπα οἶνον.
Iliad, E. 339.

Hippocrates considered caloric not only as the foundation of life, but as the Divinity itself, intelligent and immortal, the *aurai simplicis ignis* of Lucretius and the Epicureans.*

Pythagoras drew from India the first notions of an individual soul, of its existence independent of the body, and of its animating brutes, as a punishment for transgressions committed in the human frame. This doctrine was expanded, as it is believed, by Plato,† into that of the immortality of the soul, in the modern signification of the terms: and thus a separation was effected between psycologists and physiologists; since which, indeed, they have frequently come into collision, but have rarely coincided; and both by their agreements and contradictions, they have uniformly rendered confusion worse confounded.‡

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* Δοκέει δὲ μοὶ ὃ καλεόμενον θέρμον ἀθάνατον τὲ ἔιναι, καὶ νοεῖν πάντα. κ. τ. λ.—Ἱππ. πέρι σαρκων.

† There was much doubt among the ancients respecting the origin of this dogma, as Pausanias has observed. Herodotus remarks, Ἐγω Χαλδαιους καὶ Ἵνδων τοὺς Μαγοὺς πρώτους ὃιδα ἔιποντας ῶς ἀθάνατος ἐστιν ἄνθρωπȣ ψυχὴ, ii. 23. Athenæus attributes the idea to Homer.

‡ Ex divinorum et humanorum male sana admistione non solum educitur philosophia phantastica, sed etiam religio heretica.
Bacon. Nov. Organum.

The Greeks, however, in the subtilizing spirit of their philosophy, speedily discovered that one soul was not sufficient for theological and for physiological purposes; and they accordingly distinguished three constituents in the human compound, Σῶμα, ψυχὴ, and νοῦς; the body, the vegetative soul, and the divine intelligence. A fourth ingredient was also finally thought necessary, according to the testimony of the following verses:—

> Bis duo sunt homini, manes, caro, spiritus, umbra,
> Quatuor ista loci bis duo suscipiunt.
> Terra tegit carnem, tumulum circumvolat umbra,
> Orcus habet manes, spiritus astra petit.
>
> In man four principles of life we find,
> Flesh, spirit, ghost, the immortal source of mind.
> Four ways they tend. The spirit mounts in air,
> Earth has the flesh, to Hades souls repair,
> And ghosts, by lonely tombs, the lated trav'ller scare.[*]

The progress of error in this system of refinement is curious and amusing. The active powers of nature being once placed in independence of the masses, which are to be moved, they were first sought in those bodies which exhibit the greatest degree of mobility, and deviate the most widely in their properties from the grosser elements. But the mind, not yet arriving at the Που Στω of its system, pursued its abstractions, till the subject became too attenuated for the purposes of the natural philosopher; and theorists were compelled to retrace their steps, to recur to the principles of motion adopted by the earliest reasoners, and to compound a material vegetative soul to animate the mere organization; without which they found they could not proceed.

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[*] Lucian, in his dialogue between Hercules and Diogenes, distinguishes ψυχὴ from Ἔιδωλον. The former answering to manes, the latter to umbra. So also the Latins distinguished between mens and animus. Non idem est mens et animus; aliud enim est quo vivimus, aliud quo cogitamus.

Lactantius, Lib. 7.

This tripartite division has survived every revolution in philosophy; and to the present day occupies its place in the systems of nature. The "spirit of animation" of Darwin, the "*materia vitæ diffusa*" of John Hunter, answer precisely to the ψυχὴ of antiquity; being taken as the immediate cause of vital phenomena. It figured, likewise, for some time under the denomination of the nervous fluid. Girtanner supposed it identical with oxygen, and some modern physiologists have found it in electricity or galvanism. Man, physiologically considered, belongs to a numerous class of beings, and is moved on a principle common to all. The theological soul, therefore, which distinguishes him from other animals, is clearly not concerned in the organic phenomena. It is not necessary to the corporeal existence of the being, and it rests upon evidence of a very different nature. But the doctrine of the vegetative soul, whether it be taken as a spiritual essence, or a more subtile species of matter, belongs wholly to natural science, and must be tried by the canons of general philosophy.

A very little attention is sufficient to shew, that the vital principle, as well as the principle of gravitation and that of elective attraction, are merely philosophical creations, middle terms between matter and spirit, species floating between existence and nonentity, abstractions produced by the mechanism of mind and language, and resulting from particular modes of viewing the phenomena; not necessary agents, of whose existence there subsists any the slightest proof.

Our notions of action and passion, derived from our own sensations, are manifestly incorrect. Nothing is strictly passive in nature. It is by making use of the inherent properties of the several species of matter, and not by thwarting or controlling them, that man effects his operations. We usually say, than an acid neutralizes an alcali, that water dissolves salt, a stimulus excites a tissue. But in these cases neither the alcali, salt, nor the tissue are inert. There is, on the contrary, a mutuality of energy: the terms might, with perfect propriety, be changed; and it might be said, with equal truth, that the alcali neutralizes the acid, the salt penetrates the water, and the tissue attracts or repels the stimulus. It follows, then, that if a moving principle be requisite in matter, distinct from its substance, so, also, a potential passive principle must equally be necessary to enable it to be moved.*

Although the human mind, through the instrumentality of language, is capable of considering motion abstractedly from the substance in which it occurs, it cannot conceive motion independently of matter. So, likewise, though it can consider the subject abstractedly of this or that quality, it cannot divest it of all quality. Substratum, like many other metaphysical terms, is a word utterly unconnected with any positive idea. It represents nothing. From the very mechanism of mind, therefore, the causes of motion cannot be otherwise conceived, than as inherent and indestructible, unless through the intervention of notions purely fantastical, and unsusceptible of intelligible analysis.†

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* Willis, among the moderns, struggles hard for the inherent energies of matter. "Dein, quod vulgo traditur, materiam è quâ res naturales constant, esse merè passivam, et neutiquam moveri, nisi in quantum ab alio movetur, non est verum, quin potius è contra atomi, quæ sublunarium materies sunt, plurimæ adeo sunt activæ et ἀυτοκίνητοι, ut nusquam diu consistant, sed è subjecto uno in aliud passim migrent, vel in eodem conclusæ, et poros et meatus in quibus expatientur, sibi procudant.

De Anima Brut. cap. 6.

† The invention of subtile fluid principles of motion is but the placing of the elephant upon the tortoise. They must be either taken as active species of matter, or recourse must be had to the spiritual system.

The introduction of these terms, matter and spirit, leads also to another popular error, a belief that they represent individual existences; and that, however varied may be the forms and properties of different natural species, they are all intrinsically the same substance. The different elements, which conspire in producing the visible and tangible phenomena, are extremely various, and are susceptible of innumerable combinations, which communicate to each other movements from which there result forms, whose character and modes of action are very different from those which might be inferred from the nature of the constituents. It is therefore impossible to set bounds to the motive power of matter, so long as any of its possible combinations remain unknown.

The laws of vital combination, more particularly, are so imperfectly developed, the chemistry of nature is so ill understood, that it is altogether begging the question, to assert, that the phenomena of life are of a different order from those of the rest of nature. That material causes exist, sufficient to produce the differences between chemical and vital combination, and to develope the properties of sensibility and contractility cannot be doubted. That some subtile agent, analogous in its properties to light, heat, and electricity, *may* enter as a link into the chain of vital causation, is a proposition strictly possible, and is not, perhaps, altogether improbable. But till the reality of such an agency be proved, its admission upon hypothetical grounds is prohibited by that general canon of reasoning, "frustra fit per plura quod fieri potest per pauciora."

But if the adoption of a vital principle be regarded as essential to the formation of any rational theory of life, it will still be necessary to re-model the notions which are attached to that term. It must not be taken as representing a sentient principle *per se*, nor as an individual, nor as even the main cause of vital phenomena. Every element, which enters into the organic compound, is possessed of its own indestructible properties; in virtue of which, it must contribute *pro modulo suo*, to the general effect. The chemical qualities of the oxygen and hydrogen, the physical properties of the several tissues, in one word, the attractions and repulsions, elasticity, gravitation, &c. of every particle, are necessary and essential causes, and must be considered as contributing equally with the hypothetical principle to the formation and functions of the entire machine.

In denying, therefore, the necessary existence of a vegetative soul, and in pausing in our researches, at the properties of contractility and sensibility, it is not necessary to consider these boundaries as strictly impassable. But in attempting to extend the limits of inquiry, the map must be traced, after the discoveries of a Columbus; not covered with an imaginary Terra Australis, or fancied Atlantis; even though such territories should be vouched on the imposing authority of another Plato.

[illegible]

CHAPTER VI.

PHENOMENA OF DISEASE.

SICKNESS and health essentially connected—Each tissue has its own maladies. Diseases are organic or functional—General or local—Acute or chronic—Vis medicatrix—Influence of habit on disease—Contagious diseases—Instant death from excessive stimulus—Local morbid stimuli—Air and diet the two great sources of morbid stimulation. General observations on diet. Errors more frequent in quantity than in quality—Relative digestibility of different articles of food—Influence of climate on the diet. Intervals of abstinence in different animals—Preternatural fasts—Fasting woman of Tutbury—Eve Fleigen—Liquid aliment—Quantity of nourishment necessary to health—Affections of the atmosphere. Oxygenation—Barometrical condition—Hygrometrical ditto—Temperature—Moral and physical effects of climate—Of sudden changes of temperature. Regulation of temperature in disease—Influence of climate on disease—Occult qualities of the atmosphere—Inlets to disease—Diseases follow the organic balance—Maladies of infancy, puberty, manhood, old age—Consequences of inflammation in the different tissues—Sympathy—Metastasis—Incompatible diseases—Curative intentions—Impediments to the success of medicine—Estimate of the art—Modus operandi of medicines—Blood letting. Cathartics—Applications to the skin—Nauseating remedies—Diffusible stimuli—Tonics—Remedies not applicable to diseases but to functions—No real specifics—Applications to the imagination—Conclusion.

CHAPTER VI.

GENERAL OBSERVATIONS

ON THE

NATURE OF DISEASES, REMEDIES,

&c. &c.

"Verique simile est, inter non multa auxilia adversæ valetudinis, plerumque tamen eam bonam contigisse, ob bonos mores, quos neque desidia neque luxuria vitiarant. Siquidem hæc duo, corpora priùs in Græcia, deinde apud nos, afflixerunt. Ideoque multiplex ista medicina, neque olim, neque apud alias gentes necessaria, vix aliquot ex nobis ad senectutis principia perducit."

Celsus.

THE doctrines of physiology, in themselves a subject of elevated curiosity, receive their chief practical value from their application to the phenomena of disease: and as the physician derives from them the foundations of his reasonings concerning the cure of the sick, so also may the general inquirer deduce principles for regulating the conduct of the healthy.

Sickness and health are conditions so often contrasted with each other, that they have acquired in the imagination a sort of substantive character; and are scarcely recognized as mere expressions of modality. Considered as *things*, in their nature opposite and contradictory, they are rarely regarded as having any common connection; much less as being the results of the same general laws, as consequences of the same principles of action. There are, perhaps, but few educated persons, who would fall into this mistake, if the question were proposed to them in its naked abstraction; but there are still fewer, who, in the ordinary occurrences of life, do no act as if guided by such an error.

From the preceding review of the structure and functions of organized beings, it appears, that their existence is purely relative; and that they are momentarily dependent for life upon the elements by which are surrounded. Between the force of external stimulus, and that of the internal principle of reaction, a certain balance is absolutely necessary to health; and the functions are disturbed, when impressions are made upon the machine, in any other series, or degree of intensity, than those which are co-ordinate with its several necessities. The principal sources of disease must be sought, therefore, in those agents which most immediately contribute to life; and the doctrines of medicine be little more than corollaries from those physiological facts which have hitherto occupied the attention of the reader.*

Diseases, thus depending upon irregular stimulation, consist in a disturbed performance of the natural functions; and it is obvious that each tissue, as it enjoys its own peculiar mode of healthy action, must likewise be liable to its own modifications of disorder. Thus muscles are exclusively affected with convulsions; and mucous membranes are the only seat of a catarrh.

The susceptibility of every organ for disease, is twofold: it may be deranged in those actions, which constitute its specific functions, or become diseased through the affections of its nutritive parenchyma; by which its organic structure is altered. It is true that the functions of a part are rarely disturbed, without some degree of organic affection; and that organic disease cannot long subsist, without the functions becoming ultimately affected; but particular diseases for the most part bear more decidedly upon one or other of these actions; and thereby acquire a character which it is important to seize; since organic diseases are in general much less easily and certainly cured, than those which fall principally upon function. Nothing, for example, is more readily relieved than that disease of the lungs called a catarrh, however violent may be its attack; while no malady is more certainly fatal, than tubercular consumption, which is an organic affection of the same viscus.

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* "Tout moyen curatif n'a pour but que de ramener les propriétés vitales, altérées au type qui leur est naturel."

Bichat.

The excitements which cause disease, may be confined to the parts to which the morbid stimulus is applied; or they may extend to the derangement of the whole system.

General diseases may be induced by causes analogous in their operation to the diffusible stimuli: such are the several febrile contagions. They may likewise originate in stimuli of intense energy, or in applications made to organs, maintaining numerous and important sympathies in the system. Inflammations of the brain, heart, and stomach, produce the most universal and violent derangements, from their exalted vitality and pervading influence in the general economy. Erysipelas, which is an inflammatory affection of the skin, produces dangerous and often fatal commotion in the constitution, through the sympathies of that organ; while phlegmon, or common abscess, which is a similar affection of the subjacent cellular substance, requires to be extensive, or violent, in order to involve the system at large in its morbid excitement.

Organic diseases occasion in general a less violent derangement of the constitution than the functional maladies of the same viscera. But when the functions of important organs are suspended, or materially changed, the concatenation of actions being broken, the economy suffers a disturbance which is altogether independent of sympathetic influence. In this way a disease of the liver, which excites little or no febrile action, may become the cause of dyspepsia, of difficult breathing, and of dropsy; by disturbing the balance of the nutritive functions.

Diseases are likewise distinguished as acute, and chronic; according to the length of time they consume in performing their natural course. The rapidity of a disease should not however be estimated by its absolute duration; but by a comparison with the rapidity of the customary actions of the part affected. Inflammation in the cellular substance of a muscle may pass through all its stages in a few days; while in that of a bone, it will occupy as many months, to arrive at its termination. Yet both, in relation to the ordinary movements of the parts, may be considered as acute diseases. The distinction of acute and chronic malady would therefore be more properly confined to the different diseases of the same tissue.

It is a general and a necessary law of motion, whether it result from organic or from mechanical causes, that when the consequences of accidental violence, are not sufficient absolutely to arrest periodical and recurrent movements, the aberrations they occasion, are gradually diminished, by the influence of the permanent forces; and the machine ultimately returns to its primitive and regular action.* Every deviation from healthy excitement does not therefore induce disease; nor every disease terminate naturally in dissolution.

Small accidental excesses of stimulation are followed by a corresponding increase of action, which occasions a proportionate exhaustion of vitality. This exhaustion may perhaps, in its turn, become excessive; and a diminished action be thus induced, which will tend towards the opposite extreme, and accumulate excitability, in a trifling degree above par. An oscillation round the point of healthy stimulation will thus be produced, which will only subside after a certain number of librations, the excess becoming at each alternation less extreme, till the diseased movements are gradually lost, in the accustomed diurnal motions of the healthy organization.

These oscillations are frequently too trifling to excite notice, or are indicated merely by a slight acceleration in the beats of the pulse. When more violent they constitute fever, and become the subject of medical treatment.

Some excesses of stimulation are balanced by countervailing actions excited in remote organs;

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* "Dans une série d'événemens, indefiniment prolongée des causes régulières et constantes, doit l'emporter à la longue, sur celles des causes irrégulières."

La Place.

the harmony and correspondence in the discharge of the nutritive functions, affording a principle of mutual compensation. An example will explain the proposition. If too much nutriment be introduced into the system, it tends to produce an inflammatory increase of action in the constitution. The temporary acceleration of function, it thus occasions, hurries the blood in larger quantities through the lungs, and the other excretory organs. By these means, the superfluous matter, if not very excessive, is discharged from the body, without much inconvenience. It is by favouring this action, that exercise enables a stout constitution to support a certain degree of excess, with comparative impunity.

In some instances, the immediate consequences of diseased excitement tend to restore the part to its habitual functions. The inflammation of mucous membranes, if not sufficiently violent to alter the organization, is attended with an increase of secretion from their surface, by which the sensibility of the vascular tissue is gradually abated, and its actions brought back to their healthy standard. In this way the irritation induced by pieces of the cloaths, when carried into the wounds made by fire arms, causes the formation of an abscess, by which the offending cause is carried to the surface and discharged. Upon these and other similar facts, physicians have built the specious hypothesis of a *vis medicatrix*,* or governing principle, presiding over the functions, and as if by intelligence, so regulating their action, as in all cases of injury to tend towards the restoration of order. According to this theory, every disease is an effort of nature, for the re-establishment of health; and the sole admissible indications of cure are to favour its views, and to abstain from interference with its processes, except when they are excessive, and thus lead to the destruction of life.

There is a mysticism in this doctrine highly agreeable to feeble minds, and against which the strongest intellect is not always proof. In France the vis medicatrix forms the basis of professional practice, and though in England no great respect is paid to it as a guide in the treatment of disease, yet it still creeps into general reasonings, and is occasionally heard from the mouths of theorists and teachers.

There is in this doctrine a contradiction implied in the very terms of the proposition " *a regulating principle, subject to irregularity!* If there existed in the animal mechanism a curative principle, the duty of the physician would cease; for there could remain no office for man to perform where nature had placed a sentinel to guard against external violence, and a force to countermine and to obviate the attacks of the enemy. The proposition of assisting nature, when it is slow in its operations, and of repressing it when too violent, is in direct contradiction with the fundamental principle of the theory. Either the *vis medicatrix* is equal of itself to the preservation of the system, and sufficient to its own purposes, or it is a superfluous and unwarrantable term, introduced into medical reasonings, without ground, and contrary to philosophical logic.

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* Ἡ φύσις ἄλογος οὖσα, τὰ κατὰ λόγον ποιεῖ· ἱκάνη γὰρ ἔστιν, ὡς ὁ Γαληνός φήσιν. ἐν ἅπασι τοῖς ζώοις ὁρμὰς οἰκείας ἐνθεῖναι, πρός ὑγείαν τὲ καὶ σωτηρίαν, ἀπαύστως ἀγωνιζομένη.

Demetrius Pepagomenus de Podagra, p. 8.

Every action which takes place in the organization is the necessary consequence of the adjusted balance of causes, operating upon the living principle. If an unnatural stimulus be applied to the body, an unnatural excitement must follow; but that excitement can have no necessary reference to curative intention. If the disturbing force be not so great as to master the permanent and ordinary principles of motion, the balance of function must, in the end, be necessarily restored; and certain correspondent phenomena must inevitably accompany the successive stages of the progress by which the violence impressed on the machine, is neutralized and absorbed in the periodic movements.

When a wound has been made in the flesh, the stimulus of the instrument, and of the air admitted to the divided fibres, excites inflammation in them.

In consequence of this new mode of action, lymph is extravasated; and this substance becomes a nidus, in which new vessels are formed—the bonds of union between the lips of the wound. All these are effects flowing from their causes, and corollaries of the great law of nutritive action. But that they are governed by design or with reference to a specific end, is contradicted by the consequences of the same phenomena, when they occur in other parts of the body. Thus the natural consequence of inflammatory excitement in the serous membranes is adhesion between their surfaces, which interrupts the movements of the viscera they cover; and if the disease be extensive, it is necessarily fatal. In this manner the lungs are frequently bound down to the ribs, or the heart chained to the pericardium; and the functions of these important viscera being interrupted, death ensues, as an immediate consequence of the supposed efforts of the vis medicatrix.

Another instance of the inefficiency of nature to the cure of disease, and of the absence of design in her morbid movements, exists in the spasms of the intestines, which are deemed an effort to expel the offending cause. These contractions of the muscular fibre are the necessary consequences of the violence of its excitement; and are irregular and forcible in proportion as the stimulus is excessive. From a want of catenation in the movements arising out of this violence, the muscular action is much more calculated to prevent the passage of the irritating matter, than to accelerate its expulsion. The first step towards the cure consists in abating these natural movements, without which the removal of the offending cause is painfully and difficultly effected. The suppuration which takes place in tubercular consumption, in like manner, is of no service but to hurry the patient more rapidly to the grave, without manifesting the slightest tendency to the cure of the disease.

The phenomena of fever are thought more particularly to evince the existence of this hypothetical principle; they therefore merit a more detailed examination.

The symptoms of febrile disease manifest a derangement in the balance of nutritive functions, which influences to a greater or less extent those also of the relative organs. It is the consequence of a disturbing cause of considerable force; and the return to health is accompanied by many oscillations, producing the recurrence of the phenomena in a regular series.

The hot, cold, and prespiratory stages of ague follow each other in a determinate order, and recur at the end of a definite period; and all fevers which do not terminate fatally, have a tendency to resolve themselves by running a certain course of given duration. In the warmer climates, where living action is more free, these diseases usually terminate on the odd days, on that account termed *critical;* and in our own country, although more irregular in their course, they exhibit a disposition to observe weekly periods, by undergoing marked changes on the seventh, fourteenth, and twenty-first days of the malady. When a fever ceases on one of these days, the termination is usually accompanied by some notable increase of secretion, by a perspiration, diarrhœa, or hæmorrhage; and these facts have been taken as proofs of a vis medicatrix naturæ.

That the symptoms of fever are not consequences of an effort at recovery, but effects proportionate to the violence of their cause is evident. If the healthy concatenation of daily movements be not too much deranged, they will of necessity return to their pristine regularity. But if the violence of excitement be sufficient to break down these associations, and to substitute a new and morbid rhythm of organic action (unless medical interference form part of the chain of causation,) the movements will hourly deviate further from health, and will inevitably terminate in the destruction of the individual. The morbid actions, which commence in the nutritive functions, quickly effect such a change in the nervous system, as deranges its influence on the rest of the body; respiration and the movement of the heart are rendered irregular by disordered sympathy with the cerebral tissue; and the machinery, after a more or less protracted struggle, becomes completely embarrassed, and stops. Another consequence of violent febrile action is local inflammation of important viscera, which contributes rapidly to dissolution; yet these are the immediate results of the natural reaction, when unopposed by the counter operations of medicine. In ague, the phenomena are somewhat slower in their progress, but precisely of the same nature. The movements impressed by the morbific causes, associate themselves with the daily functional actions, disturb their harmony, and change the distribution of the circulating fluids. The abdominal viscera become the seats of morbid congestions; the liver, the spleen, or both these organs are altered in their structure; the pericardium thickens, and contains a dropsical accumulation; general dropsy succeeds, and inflammation of important viscera not unfrequently hasten the destruction of the victim.*

If an internal force, such as the supposed vis medicatrix, really existed, its means of cure should undoubtedly be the best possible—a proposition by no means according with the fact. The spontaneous subsidence of ague is always tedious, uncertain, and liable to relapse, not unfrequently entailing chronic disease, more injurious than the original affection: while the administration of a few doses of bark early in the complaint speedily interrupts the diseased movements, and performs, for the most part, a permanent cure.

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* The thickening of the pericardium was a frequent appearance on the dissection of the men who died of the Walcheren fever; and there existed in the advanced stages of that complaint a disposition to inflammation of the lungs, that demanded the most copious blood-lettings. Of 150 of these patients under the author's care, fifteen required the use of this remedy in one morning.

> Hi motus——et hæc certamina tanta
> Pulveris exigui jactu, compessa quiescunt.

The affusion of cold water in continued fever, and the administration of evacuents, when applied at the commencement of the disease, seldom fail in producing effects equally happy; superseding the natural movements, and preventing delirium, and other severe symptoms, which, however necessary to the process of spontaneous recovery, are never present without a proportionate increase of danger and of suffering to the patient. To assert that these movements are derangements or excesses in the curative intentions of nature, is begging the entire question; and even if this were granted, the argument would be but little amended; for that physician would be deemed but a bungler in his art whose remedies should be attended with a similar liability to fatal or unpleasant accidents.

The hypothesis in itself may perhaps be regarded as of little consequence; and if it served only as the basis of one additional false physico-theological argument, would be harmless, and unworthy of refutation. But it not only tends to render the sick too confident in the unassisted powers of nature, but misleads the practitioner in the treatment of disease. A servile observance of the operations of nature, or an endeavour to promote the critical evacuations, prevents the timely administration of vigorous remedies. Under the sole guidance of this principle of practice, the world would have lost the services of a Currie, an Hamilton, and a Jenner. Every experimental inquiry into the nature and properties of drugs has been conducted in direct opposition to, and in positive violation of this principle. Like all the other *entes rationis*, which have been conjured up by ardent imaginations, or proposed by calculating imposture, it has uniformly enfeebled action, and enslaved opinion. In every instance, that which is unphilosophical is dangerous; and that which is false, is prejudicial. Truth alone, however contradictory to existing passions, or incompatible with prevailing systems, is the sure instrument of individual happiness, and at once the lever and the balance-wheel of social mechanics.

The perturbing stimuli, which occasion disease, may offend either by their violence, or by their repetition. Against the latter mode of attack, nature has, to a certain extent, guarded by that law of vitality, which connects violence of reaction with novelty of impression. There are very many stimuli which rapidly lose their power of affecting the system when frequently applied. Opium, digitalis, cicuta, and the narcotic poisons in general, afford striking instances of this law. There are few persons who are not violently affected with vertigo, nausea, vomiting, and the other symptoms, arising from the action of this class of drugs, upon smoking their first pipe of tobacco; while, after a very few repetitions, they become scarcely sensible to it's stimulus. It is thus that individuals of strong constitution are enabled to resist, for a series of years, the injurious action of excessive quantities of wine; and (to turn from the physical to the moral world) it is thus that sights of horror fail, after a short habituation, to excite those reactions of the viscera, which constitute the emotions of disgust, indignation, and pity.*

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* The painful affection which accompanies the stronger emotions, and which is referred to the pit of the stomach, whether a cause of the mental impression, as Bichat supposes, or only a concomitant, is the index of its reality. The mere moral actions, which should accompany particular feelings, may be performed after the causes to which they relate have failed to excite emotion: because the tendency to *act* is increased by the same habit which decreases the tendency to *feel*. This is the physiological explanation of the cold, conscientious charity, which distributes money with indifference to every applicant, without sympathy, and without exertion. The generous and lively feelings that impel not only to the relief of want, but to the consolation of the afflicted, and that proceed from an actual partition in the feelings of the sufferer, are always accompanied by the organic movements above-mentioned. Hence the perfect propriety of the common phrase, which is no figure of speech, "bowels of compassion."

The several contagions by which disease is propagated, exhibit very many curious modifications of action, depending upon the influence of habit. The most remarkable instances are to be found in those febrile contagions which attack the same person but once. But almost every morbid poison loses something of its impressive force in constitutions which have been previously exposed to its action. Physicians and nurses, who are habitually environed by contagious atmospheres, are much less frequently the victims of disease, than their exposure to risk should warrant. Not only individuals, but nations become thus exempt from contagious influence; or at least suffer less violent derangement from its impetus. The leprosy, for which so many hospitals were endowed by our ancestors, has disappeared from Britain as an epidemic: and the *typhus gravior* is not only less prevalent, but less fatal in its attacks, than it was a few centuries back.*

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* This is not to be exclusively attributed to the personal immunity of the moderns. Cleanlier habits and more wholesome diet have co-operated powerfully towards abating the malignity of this disease. There is, however, another malady, whose symptoms are undoubtedly milder than they were on its first appearance in Europe, and with which the changes of diet, &c. have nothing to do. In this instance, the alteration can alone be explained by a sort of constitutional case-hardening, common to the whole generation. It may be questioned, whether the curability of this disease, without mercury, which has recently be-

That these singular exemptions arise out of the general law of habit, and do not depend upon any thing peculiar in the nature of the causes, is evinced in the cases of exception to the general rule, which frequently occur; and in which the full effect of the poison is rarely exerted, as upon its first application. When a person who has had the small-pox is inoculated for the second time, the operation may be utterly exempt from consequence; or a local inflammation may arise, followed by a more or less perfect pustule. Sometimes a few secondary pustules appear, and even a slight degree of fever takes place; and in a few rare cases, the disease will more or less perfectly run its entire course. All these various modifications of action cannot depend upon a fixed cause; but must follow from corresponding variations in the impression made upon the sentient tissues by the former attack.

The influence of habit is not equal with respect to all morbid stimuli. In some instances their force is too disproportionate to admit of its application. Where the disease springs rather from errors in quantity than in the quality of stimulation, the influence of habit operates two ways: for while by its operation on the sentient tissues it tends to fortify the constitution, by its effects in

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come the subject of experiment, be not a consequence of the diminished sensibility of the animal to its peculiar poison.

the contracting tissues, it increases liability to disease. This last consequence is particularly felt in the mucous membranes; which, when frequently excited to diseased action, become liable to fall into derangement from the slightest causes. Hence the superior susceptibility of many individuals to pulmonary fluxes, to diarrhœa, and more particularly to sore throat.

The violence of impulse, consecutive to the application of certain agents, destroys life so instantly, as almost to preclude the idea of intermediate action. The changes these substances effect in the living tissues, are too subtile to meet the grasp of intellect, either at the instant of their taking place, or in the traces they leave after death. Thus much only is known, that they act upon the more immediate causes of life; and so long as the ordinary operation of these causes lies hidden from contemplation, it is vain to attempt an explanation of their morbid affections.

The contact of the concentrated prussic or hydrocyanic acid with a mucous membrane is followed by instant death, in the most rigid sense of the word. Immersion, in an atmosphere of carbonic acid, produces the same effect, with a nearly equal rapidity. The oil of tobacco, and that of bitter almonds, suspend the relative life after a few convulsions; and by this temporary arrest of the functions of the brain, they interrupt the respiration; and thus put an absolute period to the whole living energies.

The contagion of plague and of typhus fever have also been known to destroy life, by their first impulse, without the intervention of diseased phenomena; but the great majority of morbid stimuli prove fatal, only through the inordinate actions they induce in the system.

Some highly irritating applications, such as the red-hot cautery, and the more concentrated acrid poisons, produce instant death in the part to which they are applied. When brought into contact with an important organ, they may kill by the suspension of its functions; but they more commonly destroy, in consequence of the violent reaction, occasioned in remote organs, by the death of the part primarily affected. Inflammation and fever are the general consequences of these affections.

When the death of the organ does not immediately follow the application of a poisonous substance, all the effects of excessive stimulation are observed to succeed; inflammation in the nutritive parenchyma, convulsions in muscular tissues, increased secretion from mucous and serous membranes;—these are all combined in the case of the stomach receiving an acrid poison. The heat and pain in the region of that organ, indicate the first, the spasmodic vomiting the second, and the quantity of evacuated fluids the third of these affections. When important viscera are thus excited, other symptoms follow, through the sympathetic influence of the part upon remote organs. Such are the muscular tremors and cramps in the extremities, which so frequently ensue when poisons have been swallowed.

Some stimuli exert their energy most especially upon certain individual tissues or organs, and influence the general constitution only in a secondary manner. Mercury acts peculiarly upon the lymphatic and glandular systems; cantharides upon the kidnies, and urinary system; lead upon the muscles, (more especially upon the muscular coat of the intestines,) and the narcotic poisons, in common with the diffusible stimuli, (from which they differ principally in force and concentration,) exert their chief influence upon the nervous tissue.

The effects of morbid stimuli of less activity, (of such, namely, as operate by repeated impressions,) are less easily assignable, except in their general results; whence proceeds the difficulty of detecting with accuracy the causes of many complaints produced by their agency. Gout and stone have been ascribed to a variety of contradictory causes: the origin of cancer is wholly unknown. The direct influence of spirituous potation on the liver is amongst the few well ascertained facts of this order.

The influence of deficient excitement is less easily appreciated. The increased activity of the organs, proceeding from accumulation of vitality, to a great degree supplies the want of stimulus, by reacting upon a smaller impetus. In general deficient stimulation may be presumed to produce the effect of morbidly increased excitability. Some organs, however, bear this condition better than others. When the period of life arrives which requires the developement of particular viscera, and the stimuli are not applied which should call them into orgasm, the whole constitution is deranged by the disturbance which takes place in the organic balance:* but in general the abstraction of stimulus is much more easily borne by the constitution than the opposite extreme of superabundant irritation.

The investigation of the two great sources of irregular stimulation, to which the human animal is exposed, (the ingesta and the surrounding atmosphere,) has not afforded practical results to the philosophical enquirer, proportionate to their importance in the economy; and opinion and prejudice have added considerably to the natural difficulties which surround the question.

The influence of the food upon the economy is most extensive. The daily repetition of its stimulus renders aberrations from wholesomeness a source of frequent disturbance. The nourishment acts upon the system, not only by the quantity and quality of the fluids obtained by digestion, but in virtue also of the impulse, which the stomach receives from it, as a mere stimulus ; and of the impressions which that organ, as the great centre of sympathy, propagates over the whole frame. In cases of fatigue and exhaustion, the faint and uneasy sensations are immediately removed by taking food, and subside almost with the deglutition of the first morsels, before any addition can possibly be made to the circulating fluids. The stimulating force of animal food is far superior to that of vegetable diet ; and it is to this property, rather than to any thing peculiar in its digested products, that must be attributed its invigorating force, and the peculiar character it impresses on those animals which make it their exclusive support.

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* Chlorosis.

It is in reference to this property also, that the prohibition of animal food has been adopted, as a religious ordonnance : the feeble stimulation of vegetable diet being assumed as a means of depressing the passions, together with the physical strength of the constitution. Unfortunately, however, the causes which enfeeble reaction, increase, at the same time, the mobility of the sentient tissues, and exalt the tendency to imaginative associations. The ideas thus become morbidly connected, and give birth to irregular and capricious desires, which replace the appetites proper to the physical constitution, and vindicate, by their extravagance, the outrage inflicted upon contradicted nature.*

Whatever is not capable of decomposition by the living agency of the stomach, may be considered as poisonous ; inasmuch as it will excite a derangement in the functions of the intestinal canal, which, if excessive, would prove fatal.

The converse of this proposition is not equally true ; for many substances submit to the digestive process, which possess highly acrid and irritating properties. Almost all the vegetable poisons exist, in their natural state, in combination with sugar or mucilage ; a circumstance that increases their danger, by the incitement it affords to the palate of ignorant persons and children. This fact, amongst many others, tends to disprove the doctrine of final causes, of which such frequnt application is made, as even to infect the common forms of speech ;* to the great injury of philosophy and of truth. If final causation entered into all the minute details, which necessarily flow from the general laws of matter, it must follow that there is an extraordinary combination of ingenuity and of malice, in thus uniting in one substance qualities so calculated to produce fatal consequences.

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* Mais ce but n'étoit pas le seul qu'eussent à remplir les fondateurs d'ordes . . . . de quoi s'agissait-il en effet ? De plier au joug une réunion d'hommes dans toute la force de l'âge, que la rétraite et l'uniformité de leur vie ramenaient sans cesse aux mêmes impressions, et qui pesaient longuement sur leurs moindres circonstances ; à qui la méditation contemplative et l'inexpérience du monde, en leur offrant sans cesse, des peintures chimériques de ce qu'ils avoient perdu, devoient nécessairement inspirer les idées les plus bizarres, les penchans les plus fougueux : il s'agissait de ranger ces êtres dégradés à des lois encore plus absurds qu'eux-mêmes—à des lois qui violaient et foulaient aux pieds tous les droits et tous les sentimens de la nature humaine. Il fallait faire plus ; il fallait, s'il étoit possible, leur faire approuver et chérir la barbarie elle-même de ces lois.—*Cabanis.*

As indigestibility is a test of unwholesomeness, this last property is manifestly not inherent in the substances to which it is assigned ; but depends upon the condition of the recipient. It often happens, after food has been taken, and the digestive process has commenced, that a sudden shock, such as the arrival of bad news, deranges at once the sensibility of the stomach.† When this occurs, the food, no longer in relation with the living power of the intestinal canal, becomes the source of morbid irritation ; and violent spasmodic efforts are made to expel it from the system ; which are attended with great pain and sickness. These attacks are by no means uncommon with persons of sedentary habits, or of weak digestive powers.

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* The idea of design comports so perfectly with our habitual modes of thinking, that, in physiological and anatomical description, it is almost impossible to avoid the use of expressions which imply the influence of final causes.

† Cadogan on Gout.

The properties usually assigned to different articles of diet must, therefore, be considered as applicable only in the most general sense; and as being subject to many exceptions. Almost every person, at all advanced in life, has made in his mind a catalogue of substances, which, though generally wholesome, are to himself the sources of inconvenience and sickness. Fat meat, which, when the stomach is equal to its digestion, is an wholesome and nutritious food, produces heart-burn, sickness, and vomiting, in individuals whose digestive organs are feeble and irritable.

The presence of food in the stomach solicits much action in that organ; and in persons of a weak frame, it occasions, when excessive in quantity, or stimulating force, a marked derangement in the circulating system, accompanied by flushing and head-ache. In febrile diseases, the use of such food as requires a considerable exertion of digestive power, is especially injurious; both by its direct stimulation, and by its disproportion to the energies of the debilitated stomach. The incessant tormenting of the sick to take nourishment is among the most absurd and pernicious prejudices which prevail in common life.

The more acute the character of a disease may be, the simpler must be the food administered, and the smaller its quantity. In general, solid substances, by the resistance they afford to the living energies, excite great distress in the stomach of the invalid; while the same materials, suspended in water, and largely diluted, may be employed with advantage.

When the violence of fever has subsided, it is not improbable that small quantities of light nourishment may prove beneficial, by renewing the catenation of daily habits; which had been broken up by the unaccustomed abstinence necessary in the first attack. The most guarded attention, both as to the quantity and quality of nourishment, is, under these circumstances, a duty both of the physician and of friends; since as many persons are perhaps destroyed by the injudicious conduct of this particular, as are saved by any extraordinary exertions of skill, on the part of the medical attendant.

The digestive powers of the healthy human stomach admit of great latitude. Some nations live exclusively upon vegetable food, others on the flesh of quadrupeds, and others again upon fish. Every such exclusive habit is, however, attended by some peculiar modification of the economy;*

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* Il est aisé d'observer, que même en Europe les peuples qui se nourrissent en grande partie de chair, sont d'un charactère plus porté à la ferocité, que ceux, dont la nourriture est en grande partie composée de vegetaux. Il en est de même du tempérament et des maladies qui en resultent. L'Eléphantiasis, maladie presque inconnue aux anciens Scythes, qui se nourrissoient

and the mixture of various articles of diet, such as is used by the civilized nations of Europe, seems to produce the fullest developement of the animal and intellectual powers.

The principal errors, to which mankind are subject in matters of diet, are rather to be sought in the quantity, than in the quality of their food. The repletion of the stomach being attended with the gratification of an appetite, and the digestive powers being greater than are absolutely necessary for the support of life, there is a constant and inevitable tendency in the animal, to plethoric accumulation; against which few, who possess the means of gratification, have courage to contend. If the great variety of substances, which are subservient to the pleasures of the table be classed, they will be found to yield but a very few different principles; all nearly allied to each other, in chemical properties. Fibrine, gelatine, mucilage, fæcula, oil, sugar, and acids, make up the mass of the substances, usually employed as food; and they all yield results, which, with very trifling exceptions, most closely approximate. The spices and condiments, with which they are mixed, are rarely taken in quantities sufficient to make any perma-

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de lait, n'étoit si fréquente à Alexandrie, que parceque les habitans de cette ville mangeoient habituellement diverses espèces de salaisons, et jusqu'aux chairs d'âne.

Coray, Notes au Traité d'Hippocrate sur les Eaux, &c.

nent change in the economy. Substances that are slow and difficult of digestion, produce so much inconvenience, as to discourage most persons from their habitual use ; and articles of food, obviously pernicious, are rarely employed, except under the pressure of uncontrollable necessity.

The injurious effects of luxurious indulgence may therefore more justly be attributed to the excesses it solicits, than to the specific properties of the separate articles of diet. The sensitive impressions, which these objects make upon the stomach, though not the subjects of relative perception, produce the same effects upon that organ that they do upon the palate ; exciting it to continued action, by their contrasted stimulation ; agreeably to that law, which renders a tissue sensible to a second excitor, after it has been exhausted with respect to the first. To this point all the laboured operations of cookery are directed. Acids are alternated with sweets, and with spices ; and substances, even of unpleasant flavour, are tolerated for the strength of their impressions, in order to goad the satiated appetite, and to prolong the pleasures of the table.

That the mixture of many articles of food is a cause of indigestion, is a proposition of some antiquity ;* but like many other ancient dogmas, its antiquity is no guarantee for its truth. The general agreement in character of all edible substances prevents any extensive chemical decompositions, injurious to digestion. Wine and vinegar, it is true, harden animal food; but they at the same time excite the living tissue to greater activity. In point of fact, gluttonous excess in the use of one dish, produces all the inconvenience of too great repletion, from a variety of meats. The French, who are extremely recherchés in their cookery, and eat of every thing the table presents; but who are at the same time habitually temperate, and even abstemious,* enjoy long lives, and exhibit unabated vigour of constitution to the last period of their existence.

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* ———————— nam variæ res
Ut noceant homini credas, memor illius escæ,

But though the usual articles of diet are nearly all equally wholesome, provided they be digested and are not used in excess, there is a material difference between them, in their relations to a feeble or diseased stomach. When the action of this organ is impaired, it is necessary to choose exclu-

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Quæ simplex olim tibi sederit at simul assis
Miscueres elixa, simul conchylia turdis,
Dulcia se in bilem vertent, stomachoque tumultum
Lenta feret pituita.

Hor. Sermon. ii. 2.

* One meal a day, and that by no means an abundant one, suffices for the majority of Frenchmen, if a dish of coffee in the morning be excepted. In those families in which meat is served twice in the twenty-four hours, they do not feed so largely as the inhabitants of these Islands.

sively those substances which are most readily digested, and these generally speaking stand nearly in the following order. Old flesh meat, the flesh of young quadrupeds, fowl, fish, eggs, milk, the cerealia, legumina, farinaceous roots, boiled leaves of vegetables, and raw garden productions; or to come nearer to first principles, fibrine, albumen, gelatine, vegetable gluten, fæcula, sugar, gum, animal and vegetable fixed oil, &c. With respect to these different substances, however, individual stomachs act with great uncertainty and caprice; and experience is a much safer guide to their use, than general rules.*

The quantity of food, which is necessary for sustaining life, the degree of stimulation it may possess, and the quantity of resistance it may oppose to the digestive process, without injury to the economy, vary with the climate, and the habits of the individual. In cold regions, more food is necessary to enable the animal to resist the rigours of climate, and a greater degree of stimulation is requisite for the evolution of heat, than would be endured in the equatorial latitudes: while the inhabitants of warm climates are instinctively led to the choice of vegetable food; because it stimulates in a smaller degree, and because its digestion is attended with a smaller evolution of animal heat. With persons thus situated, abstinence from intoxicating liquids is an easy virtue; and it has been prescribed by legislators, rather as a physical than a moral excellence.* Religion in its externals has its geographical limits; and rules of observance cannot be universal. Pythagoras and Mahomet, had they flourished in Scandinavia, would neither have proscribed wine, nor prohibited the slaughter of animals. It was a great mistake in those who introduced Christianity into Europe, to enjoin an imitation of the austerities practised by the anchorites of the East. By forcing the inhabitants of the North to undertake fasts uncongenial to their position, and dangerous to their health, they necessarily introduced hypocrisy, and a habit of concealed indulgence; and they laid the foundation for a casuistry the most subversive of good morals. It was not so much a spirit of luxury, as the cravings of instinctive appetite, that sought a dispensation for wild fowl (a most stimulating food) in the lent kitchens of religious communities.

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* It is not alone the elementary constitution of a substance, which contributes to its wholesomeness; the mode of cohesion influences extremely its solvability. Many articles of diet, which are difficult of digestion in mass, or when eaten raw, become wholesome and light nourishment, by division, and by culinary preparation.

The nearer we advance towards the pole, the greater is the influence of climate upon the diet. Putrid fish, which constitutes the delicacy of a Laplander, would not less outrage the stomach, than it offends the senses of their more southern neighbours; nor is the liberal use of distilled spirits productive of the same ill effects in the higher latitudes, as in the more temperate regions; it appears rather to support the vigour of vital action than to injure the stomach and liver.

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* The Italian, however depraved, seldom exchanges the luxury of iced water, for spirituous beverages.

In the inter-tropical climates, however, the vigorous tendency of the fluids to the surface does not permit the viscera to become centres of fluxion, sufficiently energetic for the purposes of life, without the aid of considerable stimulation; and the inhabitants have an instinctive appetency for spice and peppery condiments. The excess of atmospheric heat above the animal temperature makes likewise as considerable inroads upon vitality as the opposite extreme in the polar regions; and the habitual languor which prevails in these countries seems to require, or at least tolerates, a considerable use of ardent spirits, which are taken largely diluted, and in small but repeated doses.

Animals in general require a supply of food at intervals, short in proportion to the activity of their functions. Serpents and the oviparous quadrupeds endure fasts for inconceivably long periods. The Boa-constricor, brought with Lord Amherst's Embassy from India, took nourishment once only in several weeks; and a friend of the author of these pages kept for some years a toad in his wine cellar, which apparently never stirred from the spot where it had first placed itself, and probably derived its exclusive support from the few spiders and other insects which happened to pass within its reach.

Violent exercise demands a more abundant and stimulating diet than is requisite for the maintenance of a sedentary animal; but it is an error to suppose that the effects of excess are carried off without injury by great bodily exertions. Hunters, more especially, conceive themselves entitled to deeper potations than their milk-sop neighbours; and they certainly sustain them for a short time with apparent impunity. But the violent strain upon the constitution, occasioned by these alternations of hard labour and excessive repletion, shatters the economy, and is seldom followed by an healthy old age.

Man cannot be permanently sustained with less than one meal in four and twenty hours. Death, however, does not immediately ensue from inanition. Well authenticated instances are on record of persons having sustained fasts for ten or fourteen days, without fatal consequences. The differences in this respect, which have been observed in different individuals, must, in a great measure, depend upon the fat or lean state that may happen to have accompanied the commencement of their abstinence. Something also must be referred to peculiarity of constitution; for death most frequently results rather from deficient stimulation, than from the want of nutritious matter in the system, to support the vital functions.

Medical and physiological books teem with histories of long protracted abstinence. Haller quotes instances of persons who have fasted for months and even years; thereby, perhaps, rather proving his industry and extensive learning, than exhibiting the strength and soundness of his judgment. Many such stories must doubtless have originated in that credulity and love of the marvellous, incident to ignorance and to superstition; for they abound principally in the oldest writers. But more perhaps have proceeded from a spirit of falsehood in the narrators, or of scandalous deception in the supposed subjects themselves.

The recent case of the fasting woman of Tutbury was of this last description. After exciting the attention of the whole nation, by an alleged fast of many months, she was at length with some difficulty detected, and proved to be an impostor. Having contrived, in the first instance, to elude the vigilance of persons appointed to watch her proceedings, she was visited by the lovers of the wonderful from all parts of England, and she derived ample means of subsistence from the very pretence that she was superior to its necessity. At last, however, the rational scepticism of an enlightened individual* led to a second and more rigid scrutiny; and the imposition was discovered by the rapid exhaustion of the wretched woman on the tenth day of the experiment.†

How far the whole of such surprising adventures are to be considered as underserving of credit, cannot, in the present state of physiology, be ascertained. The analogy of hybernating animals seems to warrant the abstract possibility of such cases; and it is something singular, that, according to Haller, the fasters have generally been found among women, affected with hysteric, lethargic, or mental maladies, in whom the action of the brain was diseased and irregular. Another important fact is that these patients have been said for the most part to partake freely of water; and there is no ground for determining that the stomach is, in all cases, absolutely incapable of decomposing that fluid, and deriving from it some portion of nourishment.

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* If the author is not misinformed, it was principally by the activity and ingenuity of his friend, Mr. Lawrence, (whom to name is to praise) one of the most enterprising physiologists and enlightened surgeons of the present generation.

† The prototype of this lady was Eve Fleigen, a Dutch woman, who, for fourteen years (from 1597 to 1611), contrived to deceive the world, pretending that she took no nourishment but the scent of flowers. The minister and magistrates of Meurs made trial of her for thirteen days successively, without detecting her imposture. Her history was translated from the Dutch in 1611. Over her picture in the Dutch copy are these verses:—

Meurne hæc quem cernis, decies ter sexque peregit
Annos, bis septem prorsus non vescitur annis,
Nec potat, sic sola sedit, sic pallida vitam
Ducit, et exigui se oblectat floribus horti.

This maid of Meurs thirty-six yeares spent,
Fourteene of which she tooke no nourishment.
Thus pale and wan she sits sad and alone,
A garden's all she loves to looke upon.

"*An Apologie, or Declaration of the Power and Providence of God,*" *by George Hakewill,* fol. 1635, p. 440.

Of the several substances taken into the human subject, those which are used in a liquid state are by no means the most indifferent; being not only employed with the smallest reference to the natural appetites, but also the most compound and artificial in their respective characters. For the mere purpose of dilution, however, water may be considered as the universal beverage, since it is the basis of every composition used for quenching thirst. It is seldom employed in a state of perfect purity, and indeed seems to be rendered more wholesome by a copious impregnation with air. In wells, it often contains small portions of sulphuric acid, and minute quantities of earthy salts; at other times it contains lime and iron, suspended by carbonic acid, without being thereby rendered unfit for drink, or deemed merely medical. These slight impregnations are not unwholesome; and they do not prove, as is vulgarly imagined, the causes of gravel and stone.

The water of running streams is usually more pure than that of wells, and on that account is more insipid and mawkish. When, however, they pass through low marshy districts, the water dissolves the putrid animal and vegetable matter of the soil, and it thus becomes a frequent cause of diarrhœa and dysentery.*

The water obtained from melted ice and snow is remarkably pure, but it contains no air in solution, and is therefore heavy and oppressive to the stomach. It has unjustly lain under the imputation of causing those scrofulous swellings of the bronchial glands, to which the inhabitants of Alpine valleys are subject. That disease, however, is no less frequent in Sumatra, where ice and snow are never seen, while it is entirely unknown in Thibet, where the rivers are supplied exclusively by the melting of the mountain snow.

Of the liquors artificially prepared for the use of civilized man, the simplest are the impregnations of sapid vegetables; which relieve thirst by gently stimulating the fauces, as well as by their operation as diluents. Saccharine and farinaceous decoctions satisfy at once both hunger and thirst. Fermented liquors likewise usually contain some undecomposed sugar, and are consequently possessed of nutritious qualities: but their leading property is that of intoxicating. Beer, likewise, contains an infusion of the narcotic bitter principle of the hop, which contributes much to the evils resulting from its excessive use. New beer contains a considerable proportion of undecomposed sugar and fœcula: by time the whole is converted either into alcahol, or vinegar. In strong beer the vinous fermentation predominates; in the weaker sorts, it is the acetous which prevails; but almost all old beer is hard: that is, it contains some vinegar in its composition. On this account it disagrees with feeble stomachs, in which acid is habitually present, from the imperfection of the digesting functions.*

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* The water of the Seine is remarkable for producing violent effects on strangers; yet Parmentier reports it to be purer even than Bristol water. It contains, by his account, five grains only in the pint of foreign matter, which is chiefly selenite, calcareous earth, nitric and common salts. But as the water taken above and below the city of Paris exhibited no cognizable differences, it is evident that chemical tests cannot discover animal and vegetable matter, when suspended in minute quantities.

The constant use of beer has been accused of generating stone. If history is to be believed, more men of eminence died of this disorder a century or two back, than now perish from it, in every rank of society; a fact which has been attributed to their more abundant use of malt liquors. This difference, if it exists, will be better explained by the superior rationality of modern habits, and greater sobriety, with respect to fermented liquors of every kind.*

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* The addition of a few grains of carbonate of potash corrects, to a certain extent, the unwholesomeness and the disagreeable flavour of hard and sour beer.

Wines vary considerably in their constitution. In hot climates the grape ripens more completely, and the wines are sweet and luscious; contributing more abundantly to nourishment. The Spaniards and Portuguese, however, push the fermentation so far, as nearly to decompose all the sugar of their rich grapes; and their wines are principally characterized by strength. The Rhenish wines are strong, but abound in acid. The French wines maintain a middle character, and are, on that account, the most wholesome. Legislators do not, therefore, consult the health of the people, in laying on these wines so heavy a duty, as to prevent their general use: but it is not the least evil of long continued and unnatural warfare, that it necessitates an expenditure which must render every consideration, moral and physical, subaltern and secondary to fiscal objects, and to extortion of the last possible shilling for the public purse.

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* Haller praises beer as a preventative of stone, and quotes Cyprian, as affirming, that of 14,000 persons, cut for this disease, none were beer drinkers. Bottled beer, by the carbonic acid it contains, may perhaps operate as a solvent, on some species of calculus; but vapid sour beer, by injuring the tone of the stomach, may justly be suspected of contributing to the disease. The uncertainty which prevails on these points is not very flattering to the medical art, nor to its practitioners. "Profecto eos ipsos qui se aliquid cèrti habere arbitrantur, addubitare coget doctissimorum hominum de maximâ re tanta dissensio."

Cicero de Nat. Deorum.

Distilled spirits, as Haller has justly observed, should rather be considered a poison, than a beverage; for they are nearly deprived of aqueous mixture, which is unquestionably essential to the nature of drink.* The abuse of undiluted spirits speedily exhausts the sensibility of the stomach, and (independently of its inebriating effects) does injury by condensing the substance of the stomach and liver; which leads to their final disorganization. In the reign of George the Second, it was calculated that the annual baptisms, within the bills of mortality, were reduced from 20,000 to 14,000, in consequence of the injury done to population by this destructive liquor.†

Tea and coffee are both stimulating drinks, and dispel sleep in those constitutions which are unaccustomed to their use. Coffee contains unburned farina, and is therefore slightly nutritious: but tea is a mere stimulant, and does not nourish except by the sugar and milk, with which it is taken.

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* The word intoxication etymologically implies *poisoning*: and it should more appropriately be confined to the madness produced by distilled spirits. Drunkenness, on the contrary, means *saturation with drink*, and better describes a sottish ingurgitation of the less stimulating fermented liquors.

† Between the years 1720 and 30 the average christenings were 18,203. Between 1740 and 50 they did not exceed 14,457.
Black's Comparative View.

Both tea and coffee have been made the subjects of severe diatribes; but they appear rather to have contributed towards amending the national constitution, by checking the propensity to drunkenness, than to have injured it by exalting the irritability of the sentient fibre by their specific stimulus.

With respect to the absolute quantity of food necessary to sustain life, different opinions prevail. From seven to eight pounds per diem is the average quantity consumed in this country. Cheyne allowed only 4½ pounds as a healthy quantum. But in estimating the quantity of food, its nourishing qualities should first be determined; as a smaller quantity of animal than of vegetable matter suffices for the support of existence. Cornaro subsisted upon twenty-six ounces daily; consisting of bread, eggs, and farinaceous decoction.

A greater latitude is allowable in the quantity of drink; the demand being regulated by the varying action of the secreting organs. The average proportion of drink to meat has been differently estimated. Sanctorius rated it as ten to three; Cheyne as two to one; and Cornaro took but fourteen ounces of drink to twelve of solid matter. Numbers, however, are by no means applicable to this subject. More drink is requisite in warm weather than in cool; more in a dry than in a moist atmosphere. A greater quantity of fluid is necessary during exercise, than when the subject is at rest; and more is used with stimulating, than with simple diet. A considerable latitude is allowable, both as to food and to drink, without immediately endangering the health: but a sparing and abstemious diet is the most favourable to the developement of the faculties both of mind and body.

The stomach, in civilized society, is the great inlet to disease; the mass of mankind being divisible into those who have not enough, and those who have too much, for the support of life. Both classes pay the penalty of the want of adaptation in circumstances to their physical necessities: but, in estimating their respective sufferings, it is always to be remembered, that those of the rich are voluntary. Even in middle life, the greater number of persons *live too well.* There is a decent gravity about the sin of gluttony, that comports well with the hypocrisy of professional life: while its enjoyments afford some compensation for other indulgences, deemed incompatible with a reverend seeming. As a general rule *parcâ quod satis est manu*, may be taken as the measure of this, as of all other appetites, and wants of humanity: for satiety, both moral and physical, is the grave of pleasure; engulfing present delights, and casting a gloom over the future.

——————Voluptuous man
Is by superior faculties misled;
Misled from pleasure, even in quest of joy.
Sated with nature's boons, what thousands seek,
With dishes tortured from their native taste,
And mad variety, to spur, beyond
Its wiser will, the jaded appetite.
Is this for pleasure? Learn a juster taste,
And know that temperance is true luxury.*

The nature of atmospheric influences—the other great source of irregular stimulation—is by no means thoroughly understood. It has been satisfactorily proved, that the quantity of oxygen is nearly the same in all regions, in the crowded theatre, and on the bleakest mountain. The affections resulting from atmospheric impressions, have, therefore, no immediate relation to the respiratory function. The barometrical constitution of the air is more potently influential; but it is difficult to separate the effects of variations in the elasticity of the atmosphere, upon animal existence, from those which proceed from its concomitant changes in moisture and dryness. The barometrical pressure of the surrounding air is necessary to the maintenance of an equilibrium between the solids and fluids; and it regulates the expansion of the several gaseous and aqueous constituents of the body, no less than the similarly constituted substances of the inorganic world. The full force of this cause is manifested in the use of cupping glasses; which causes a a gush of the fluids to the part over which their application creates an artificially rarefied atmosphere. There are few persons of a frame so hardy and vigorous, as to be unaffected in their sensations by this cause. When the air loses considerably its elastic power, the body is deprived of a certain portion of its force: the "pleased alacrity, and cheer of mind" passes away; and a general listlessness, an oppression of the respiration, and slight head-ache supervene; especially in the more sensitive and irritable constitutions. An increase in the elasticity of the atmosphere produces, on the contrary, an exaltation of the reactive power in the constitution, an increased intensity of thought, sensation and action, giving activity to the functions, and conferring a charm on existence, independent of circumstances, and distinct from motive.

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* Armstrong's Art of Health, b. ii. l. 151.

A permanent excess of moisture in the climate begets a corresponding dilution of the fluids; which constitutes the phlegmatic temperament, and occasions a sluggishness in the actions of the living solids. An opposite condition of the climate leads to contrary results in the animal system. It is, however, more than probable that much of these effects arise out of certain chemical changes, which the different degrees of moisture produce on the surface of the earth, rather than upon the primary influence they exercise in the constitution.

Sudden alternations of moisture and drought exert a deleterious influence upon the human economy, but their effects are more perceptible in disease, than in health ; and they depend perhaps principally upon the variations of temperature, occasioned by a greater or smaller quantity of evaporation.

The effects of temperature are more marked, than those of any other affection of the surrounding medium. An equable and constant climate developes the organization and powers of animals in the happiest way. In very warm latitudes the progress of life is more rapid, and therefore sooner exhausted. The passions are fierce, but transient ;* and the muscular system, not developed proportionately to the sensitive tissue, does not yield itself to great or continued exertion, nor form a sufficient counterpoise to the impulse of the passions. In the very cold climates the whole energy of vitality is expended in maintaining temperature. The vital forces are concentrated upon the nutritive functions, and the relative organs are but moderately susceptible. The passions are feeble, the organization is developed at a more advanced period of life, and the animal is smaller in stature.

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* "En Espagne, par example, l'amour est une véritable fièvre, un delire qui ne cesse souvent qu'avec la vie. Au commencement de ce siècle, dit l'Abbé Richard (Histoire de l'Air) on connoissait dans ce pays une secte particulière de ces amoureux en titre, et par l'état, qui peut-être y subsiste encore. On les appelloit, '*embevecidas*,' (enivrés d'amour) et il leur étoit permis d'étaler leurs transports publiquement."

Coray, Edit. d'Hippocrate.

Sudden and violent alternations of temperature induce disease, by deranging the balance of functions; especially when they affect only parts of the body. A stream of cold air from a crevice or keyhole, by reducing the temperature of the part upon which it falls, increases its sensibility so far, that when a recurrence of the habitual temperature takes place, inflammation is a necessary consequence. This is the ordinary origin of catarrhs and rheumatisms.

Cold applied to the feet, especially that produced by the evaporation of moisture, induces a sympathetic affection of the lungs, (more particularly when these organs are feeble) and thus lays the foundation of consumption and other pulmonary diseases.

The habitual application of a very high temperature produces many of the effects of a warm climate. The Russian women of rank and fortune have the same precocious developement of organization, as the more southern Asiastics, in consequence of their abuse of hot baths, and incessant attention to fencing out the rigours of their insupportable winter. In a lower degree, this excess debilitates the tissue of the skin and lungs, by exhausting its vitality; and it thus renders the subject more liable to take cold, or otherwise to suffer from the inclemency of the seasons.

Intense cold produces mortifications, as has been before stated, by exhausting the vital energy; or it kills by suspending relative sensibility. Intense heat, when it burns, operates in a similar way; but as applied in the atmosphere, it exhausts equally the sensibility of all the organs; and the victim perishes, tormented with thirst, and sensible to the last.

The influence of cold and heat, like that of all other applications, is relative to the condition of the recipient. In a stout constitution, a cool atmosphere operates an increased developement of vitality, by the reaction of the system. The blood, repelled from the surface, accumulates in the central viscera, and the heart thus stimulated, beats with additional vigour; while the nervous system is roused to an increased energy. The blood thus returned upon the surface, acts upon the accumulated sensibility of the skin. A general glow is felt in that organ, which, if not excessive, is extremely agreeable. This condition, if supported by exercise and a sufficient diet, will continue for many hours, before the subject is exhausted by its own efforts.

In feeble frames this reaction of the constitution is so trifling as scarcely to be distinguished.

The first impression of cold is intolerable. The blood, driven to the interior, fails of exciting the heart, and occasions a sense of oppression, from the vessels being distended beyond the force of their resistance. It is this feebleness of reaction, which predisposes to chilblains; the exhaustion of the surface being carried so far, that the slightest increase of temperature excites inflammation, or even mortification, in the part affected.

Extremes of heat and cold in the atmosphere, are alike unfavourable to the sick; their diminished or embarrassed energies not being equal to the efforts necessary to preserve the animal heat at its proper standard. In these climates the chamber of an invalid should rarely be heated above 60° of Farenheit's thermometer. Some particular diseases however require different arrangements in this respect. In pulmonary complaints equality of temperature is of extreme importance; and the heat should never be depressed bolow 60°. Febrile diseases demand a constantly low temperature. The prejudices in favour of an heated chamber, in eruptive fevers, are beginning to disappear. In small pox, more especially, its ill consequences are acknowledged, wherever there are good practitioners to direct public opinion. But in measles, there is still prevalent a pernicious anxiety to preserve a warm atmosphere round the patient.

Another cruel and even fatal error, that has too long obtained credit, is the belief that insane persons bear excessive cold without injury. On the contrary, they are more subject to mortification of the extremities, from this cause, than other persons.

A vehement dispute has long been carried on among philosophers, respecting the effect of climate upon national character; many writers attributing every thing to this one cause, and more perhaps denying its influence altogether.* The opinion of Strabo,† which lies between the two extremes, is more philosophical, and approaches nearer to the truth. For in the life of a creature, whose existence is totally relative, every constant application must produce its definite modification.

There is in nature a circle of cause and effect, which renders moral and physical facts mutually dependent upon each other: but as in general the physical circumstances by which man is surrounded are the primary causes of his moral affections, a certain degree of precedence must be given to their agency, in estimating particular cases. The physical combinations of inorganic nature must in point of time have preceded the existence of the animal, and consequently have determined in the first instance his moral peculiarities. There can be no question, that a soil and climate, to a certain degree sterile, are the parents both of mental and bodily vigour in the inhabitants.[*]

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* Hume, in this country, and Helvetius, in France, are the most eminent writers on the side of moral causation. Hippocrates and Montesquieu are the best authorities on the side of physical influence.

† *Τὰ μὲν φύσει ἐστι ἐπιχώρια, τὰ δὲ ἐθεσι καὶ ἀσχησει.*
Strabo, l. ii.

> Ἁι ϖενία Διοφαντε, μόνα τας τέχνας ἐγείρει
> Ἀυτα τῶ μόχθοιο διδασκαλος.[†]

The resistance which external objects afford to those actions, which are performed by organized beings, is the powerful source of that interest, which begets attention, and excites the intellect. The ideas are commonly false or incomplete, concerning those objects over which the animal holds an undisputed control. It is only when they afford obstacles to volition, that they call into play address and ingenuity, as supplements to force; and occasion an intimate acquaintance with all their properties.[‡] But in stimulating the industry, and evolving the mental powers, they give origin to many artificial impulses, and bring into play a variety of moral causes, to modify their own primitive influence. The arts to which they give birth, by the physical alterations they occasion, and by inclosing the population in houses and in the cities, amidst the artificial luxuries and abundance of commerce, efface by degrees the characteristics which nature in the beginning had impressed upon the race. Wherever mankind have been numerous, that is to say, wherever they have been stimulated to great mental developement, and consequently to the establishment of a tolerable form of government, they have to a considerable degree changed the character of the soil and climate; and to a corresponding extent, produced a new modification of themselves, which might be termed the '*civilized temperament.*'

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[*] It is in this sense that Hippocrates has observed, Ἁι μεταβόλαι ἐισι τῶν παντῶν ἁι τὲ ἐγείρουσι τὴν γνώμην τοὺ ἀνθρώπȣ, καὶ ȣ̓κ ἐῶσιν ἀτρεμίζειν.

[†] Theocritus.

[‡] Hence the feebleness and ignorance of despotic governments; and the energy and activity of counterpoised authorities.

Thus the physical circumstances act upon man; and man reacts on nature; until both are changed, and both perhaps improved. But the moral agency is still dependent upon, and proportionate to the physical causes, in which it originates.

In warm climates, the animal necessities are fewer, and more easily gratified. The greatest exertions of human intellect are made in fencing out cold, and accumulating in-door enjoyments; and with these the natives of tropical climates can well dispense. Clothes, fuel, and well constructed habitations, are to them superfluities; and the cheap and accessible pleasures of nature afford occupation and delight to the constant dwellers in the open air. Food likewise in the warm climates is abundant, and raised with little culture. Among nations thus situated, the incitements to intricate combinations, and to persevering exertions, are few and of rare occurrence. Their impulses to thought and action lie chiefly in the overboiling passions, by which they are consumed. Love, jealousy, superstition, fury, together with their consequences, hate, vengeance and warfare, are the prime movers of volition under these circumstances; and where these passions do not operate, listlessness and indolence afford the dearest enjoyments. Independent of property and of civilization, the people so situated set but little value upon forms of government; and they submit the more readily to tyranny, because it diminishes but little from the sum total of their pleasures or their happiness.

In the colder regions, on the contrary, nature has done but little for man; and it is by combined and continued labour that he snatches from her reluctant hand a scanty and precarious subsistence. To support the incessant warfare with the elements, property must be accumulated, and exertion become persevering and connected. The security of the one, and the independence of the other, are therefore rendered essential to the prosperity of the species; and an arbitrary government, inhumanly administered, is necessarily productive of a scanty, desolate, and diseased population. Under the influence of such necessities, the relations of society become closer and more intricate. A greater degree of ingenuity becomes necessary for their regulation. Minute codes of laws give birth to subtiler disquisitions in morals, jurisprudence, commerce, and statistics; and natural philosophy is extended by the reiterated experiments of artisans and mechanics. Knowledge, of every kind, in short, being power, it is eagerly sought to supply the natural feebleness of the animal, when thus opposed to a barren soil, and an inclement sky.

These are physical combinations, for the most part too strong for the animal; and in the few instances in which they have been overcome, it has been by causes of a local and temporary influence.* Generally speaking, the inhabitants of hot countries have, in all ages, exhibited their appropriate characteristics, with an undeviating uniformity; and the northern nations have equally manifested a constant *nisus* towards liberty, commerce, and scientific improvement. An uniform and universal amelioration in the condition of the species, under all latitudes, seems, therefore, a physical impossibility: and it may even be doubted, whether civilized combinations can be rendered permanent in any one region. The European emigrants to South America and to India acquire a change in moral character not less striking than that of their complexion: while, on the other hand, many moral characteristics remain attached to the soil, and manifest themselves in its inhabitants, at the end of centuries; notwithstanding that emigration and conquest may have introduced new stocks, from remote countries, and have changed very many of the national habits.

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* Tyre and Carthage afford the principal instances of free commercial states subsisting in very warm climates. Alexandria derived its mercantile energies from Greece and Rome. The magnificent cities of Asia owed their existence to military conquerors, who, having subdued large tracts of country, founded capitals, and stimulated industry, to gratify their own spirit of luxury. These, however, were unnatural combinations, and when the cause was removed, the people relapsed into obedience to their mere physical propensities. In our own colonial establishments, the European character is alone maintained by the constant influx of fresh settlers.

These remarks become more striking, when applied to the diseases which arise from climate and exposition. The more uncultivated the earth may be, and the more its inhabitants are exposed to the inclemencies of the seasons, the more marked are the influences they receive from circumstances of locality. Observations of the different constitutions of weather, and of local aspects, as connected with prevailing epidemics, have consequently become less attentively collected by physicians, in proportion as civilization has sheltered the human race, and given a greater uniformity to the earth's surface. The operation of this cause is abundantly evident. There is, to take a single instance, a peculiar vaporous exhalation, the product of animal and vegetable decomposition, abounding in marshy and uncultivated soils, which renders many unfelled districts, in the warmer climates, totally uninhabitable, by the fatally malignant fevers it generates.* In the more temperate regions, this poison is the fruitful parent of agues, diarrhœas, dysenteries, visceral obstructions, and dropsies ; and of a peculiar temperament, or constitution, unfavourable to long life. Wherever cultivation has succeeded in draining marshes, this deleterious vapour has been expelled ; and countries, formerly sickly and unwholesome, have been thus rendered the abodes of health and cheerfulness.†

Warm clothes, plentiful fuel, and an abundant supply of food—the rewards of social energy, materially contribute towards abating the influence of atmospheric causes; while the new forms of disease, introduced by the products of art, and by the habits of social life, have perhaps still further modified their operation; at the same time that, by fixing the attention of practitioners, it has predisposed them to disregard the general circumstances of countries, and to study the more particular causes of disease. Notwithstanding, however, the utmost efforts of man, there still remains an impress of nature in the characteristic diseases of different climates, which cannot wholly be overpowered, or resisted. Not only peculiar maladies, but a peculiar temperament prevails in different countries, which modifies the methods of cure, and diversifies the medical aphorisms by which the art is governed in each.*

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* See Dr. Bancroft's manly and philosophical investigations on the subject of contagion.

† This is the case with the county called Berwickshire in Scotland, which, within the memory of man, was a remarkably sickly district. The *mal aria* of Italy is said to prevail where the land *is* cultivated; but there is a deception in the term. A moderate degree of culture in a genial climate will repay the labourer with a plentiful crop ; and perhaps the more so for this very moisture. But the culture here demanded, consists in a perfect system of drainage, such as can only be undertaken where labour is protected, and its reward rendered certain by a good system of government. The difficulty of destroying the *mal aria,* which has so long subsisted in Italy, proves, to demonstration, the intimate connection between a free constitution, and that command over the physical elements, which is, for the most part, so essential to the well-being of the human race.

Besides the sensible or ascertainable properties of the atmosphere, it may be questioned, whether, under certain circumstances, it does not manifest, in its influence on health, the existence of others, which have hitherto escaped investigation. The influence of marsh miasma, and of peculiar expositions upon health, had been ascertained by observation, long before the effects could be traced to their specific causes. The peculiar consequences of these causes were, therefore, attributed to occult properties, the immediate parents of endemic disease. A specious analogy extended this mode of reasoning to those epidemics, which, appearing for a season, affect the majority of the individuals, in the district where they rage. The dreams of judicial astrology by degrees also mixed themselves with these general notions; and the cause of epidemics was sought in malignant astral aspects; explainers thus recurring to their usual felicitous exposition, *ab ignoto ad ignotius*. Many epidemics, formerly attributed to these causes, such as the plague, small-pox, measles, &c. &c. have, since the commencement of real learning, been traced to the operation of especial morbid poisons, soluble in the atmosphere, and capable of generating disease, by their contact with the body, under laws peculiar to each specific virus.

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* Οὐ γὰρ πάντες τόποι τὰ αὐτα φέρουσι βοηθήματα διὰ τὸ μὴ πάντα τὰ περὶ ἔχοντα ἐξ ἀέρος ὅμοια εἶνα.

Ἱπποκρ. Ἐπιστολαι.

The discovery of these morbid poisons (as they are called) and the repugnance which a spirit of philosophy has generated, to admitting occult causes in the explanation of natural phenomena, have materially contributed to discountenance the doctrine of atmospheric constitutions, independent of the known ascertainable properties of the circumambient fluids. But it may with great reason be doubted, whether this new course of philosophizing has not lead to the opposite vice of multiplying contagions, upon slight evidence; and of attributing epidemics to the agency of these poisons, which, in fact, depend upon other and more general causes. The question is not one of easy solution; and as it involves in its consequences police regulations, affecting domestic and daily habits, it is one in which the passions, of necessity, must largely mix. Testimonies as to fact, the most opposite and contradictory, have been adduced by medical authorities, the most repectable for moral and scientific eminence. The question is far from decided; but the present is by no means an occasion for entering at large upon its investigation.

From the forgoing observations it appears, that the atmosphere is capable of injuring health, chiefly through the substances it may hold in solution. These are caloric, water, the infectious miasmata of marshes, and the effluvia escaping from the bodies and clothes of persons labouring under certain contagious diseases. In a few instances the air is also capable of holding suspended certain of the mineral poisons, and of thus becoming a cause of malady. Mercury and arsenic, thus brought into contact with the body, attack the constitution of the artisans employed in manufactories where these minerals are employed.

The inlets to malady are as numerous as the surfaces susceptible of stimulation; but the same substances are not equally active when applied to every tissue. The odour of flowers, when powerful and concentrated, produce fainting in irritable subjects, by their impression on the olfactory nerves; but they are innocuous, when applied to all other parts of the body. The oil of bitter almonds, so suddenly fatal when placed in contact with a mucous membrane, produces no sensible effect, if applied immediately to the brain. The poisonous extract, called *worrara*, destroys life only when dissolved in the blood; but the oil of tobacco is deleterious both in the circulating system, and on the mucous membranes.

So, likewise, the vaccine virus acts only when in contact with the skin, stripped of its cuticle; whereas the variolous poison excites disease, by contact with mucous membranes, either in substance, or dissolved in the atmosphere. The contagious matter of plague infects by the slightest contact.

From these differences it appears that some deleterious substances act upon the vitality of the mucous membranes exclusively, and that others require to be received into the circulation to affect the system; where they may act, either by altering the constitution of the fluids, or, more probably, by their influence upon the sensibility of the capillaries. Among the latter class some substances, by a more active and subtile virulence, find their way through the cuticle to the absorbents of the skin, and so pass into the circulation; while others, less active, or less attenuated, are unable to pass that barrier; and become effective only when in contact with wounded surfaces.

Poisons, which enter the system through the skin, may be stopped *in transitu* by an early excision of the part affected, before the absorbent vessels have removed the virus from the spot where it was deposited: a mode of proceeding which forms the established preventative of hydrophobia.

The course of some morbid poisons towards the circulation is marked by inflammation of the absorbing vessel, by which it is conducted; and a local disease thus precedes the constitutional affection. Generally speaking, however, the susceptibility of the different tissues for morbid impressions is proportionate to the activity of their functional actions.

In illustrating the causation of disease, the action of poisonous substances has been preferably chosen, because they are at once more tangible and more evident in their energies: but the influence of all morbific causes is alike; and consists, essentially, in an alteration of the sensitive force of the tissue upon which they act. But though the mode in which disease arises be thus generally assignable, the causes of each specific change are by no means equally clear. Many maladies are attributed by physicians to a variety of causes; which is a sure testimony that the real agent has escaped detection. Others are said to arise spontaneously in the economy;—a form of speech expressly calculated to conceal the ignorance of him who uses it, and openly contradictory of the fundamental maxim of *no effect without cause.*

Morbid excitement, like the consequence of all other stimulation, varies with the condition of the recipient. If any particular organ be relatively feeble, that part will be more likely to suffer than another, from a general cause. The balance of functions, also, which leans towards different organs, in the successive stages of life, produces a peculiar tendency to certain diseases, at each peculiar epoch.

As far forward as the middle of life, the balance of circulation lies on the arterial system. Young persons are, therefore, peculiarly susceptible of inflammatory diseases. In the earliest infancy the force of arterial circulation predominates in the head and upper extremities; a fact which is marked by the imperfect developement of the legs and thighs before birth. Convulsive diseases, epilepsy, St. Vitus's dance, and that fatal malady hydrocephalus, are consequently prevalent affections of infancy and childhood. Towards the epoch of puberty the balance of arterial action inclines towards the thoracic viscera; and inflammations of the lungs and pulmonary consumption are the attendant maladies. At this period, too, a spitting of blood is not unfrequent, which supersedes the bleeding from the nose, so common in plethoric children. As life advances, the arterial force declines, and plethora is chiefly felt on the veinous side of the circulation. Hence the liver, which derives the supply of its functional actions from the veinous blood, becomes peculiarly liable to disease. In some subjects, however, the strain upon the veinous system is more immediately felt in the vessels of the head, which induces lethargy, apoplexy, palsy, &c. &c.*

In early life, the general intensity of vital energy occasions a more violent reaction upon morbid stimulation, which is manifested in the acute character of the prevailing diseases. Worms and acrimonious matter in the *primæ viæ* cause fever and convulsions in infancy, though in after life they produce but trifling inconvenience. To this cause, also, must be attributed the greater mortality from hooping cough, measles, and small-pox, in proportion as the subjects they attack are younger; as also the greater degree of irritation and consequent danger incidental to the cutting of the first set of teeth. This process frequently occasions convulsions and derangements in the functions of the intestinal canal; phenomena which do not in the slightest degree accompany the appearance of the second set at a more advanced period of existence.

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* It is by relieving this veinous plethora that the hæmorrhoidal flux, whether naturally or artificially excited, becomes serviceable in preserving health in persons advanced in life.

The local diseases, which given excitements may induce, are in like manner proportionate to the vitality of the organ upon which the stimulus operates. Inflammation in parts abounding in cellular substance, commonly ends in the formation of an abscess; and when the mucous membranes are thus affected, their peculiar secretion is exchanged for that of a substance, differing but little from the pus which abscesses contain. Inflammation of the serous membranes occasions the effusion of coagulable lymph, constituting a nidus, in which new blood-vessels rapidly form, and unite the contiguous organs, and impede their functions.

Glandular inflammation is prone to terminate in indurations of the substance of the part, or in a total change in its organization and functions. Thus accidental blows frequently become the occasional cause of cancer. In parts of lower vitality, inflammation, if excessive, terminates at once in the death of the affected tissue, which is afterwards separated from the sound parts by the living energy of the surrounding absorbents. In bones, this process, which is tedious and painful, is termed exfoliation.

The fibrous organs, which do not abound in cellular substance, seldom suppurate: they do not bear inflammation well, and are easily driven to mortify. Gout and rheumatism, however, which are inflammatory affections of these organs, resolve themselves without destroying life by the deposition of calcareous matter; which, when excessive, impedes the functions of the joints, and causes permanent lameness. Acute inflammation cannot take place in any important viscus, without inducing that general affection of the circulating system which constitutes fever. In these cases, the cure of the local disease resolves the constitutional affection. But when fever arises from the agency of general causes, it may be removed by attacking the symptoms.

The diseased action of one organ not unfrequently excites another to sympathetic malady. One eye, one lung, one kidney, may thus draw the corresponding organ into inflammatory action. So also the subsidence of disease in one part may be accompanied by its reappearance in another; even of a different tissue. Thus in that affection of the parotid glands, called "the *mumps*," the breasts frequently swell, and become inflamed upon the subsidence of the primary disease. The secondary affections of the head and stomach in gout and rheumatism, are of daily occurrence, and of fearful notoriety.

There are, on the other hand, diseases incompatible with each other. The eruption of small-pox and that of measles, do not simultaneously proceed in the same persons; and certain chronic eruptions are a sufficient cause why vaccine inoculation should not take effect.

As diseases arise from irregular stimulation, so they are cured by applications which counterbalance its consequences. The powers of art, as was before observed, have seldom been accurately appreciated; many are inclined to treat medicine as an idle dream; more are disposed to place in it an unbounded and religious confidence. The philosophical physician would perhaps rather think of it according to what it may become, than with reference to what he feels that it actually is.

It is impossible that diseased action should long subsist in any organ without inducing morbid structure; and as no organ subsists in perfect independence and isolation, the disease must ultimately extend itself to other parts, connected in action with the primary seat of disease. In the nutritive system especially, the harmony of function is so delicate, that, *de proche en proche*, the whole economy becomes diseased from a permanent affection of any of the more important viscera. Thus condensation and obstruction of the liver disturb the chylopoietic functions, inducing emaciation, and general or abdominal dropsy. In proportion, therefore, as a malady has long subsisted, its symptoms become complicated and equivocal, and its cure operose. Time consequently is among the most important elements in the treatment of disease, and operates as one of the leading causes of the little success which is said to attend the practice of physic. Where morbid action is of a violent and acute kind, the importance of this point is manifest to a common observer. Inflammation, for example, in a vital organ, rapidly produces such changes in its structure as are incompatible with its functions. Before this takes place, depletion carried steadily on to the point which counterbalances the stimulating cause, will relieve the disease as effectually as if seated in an organ of the least importance; but when the change of structure has taken place, the powers of art are at once circumscribed, and the physician becomes little more than an anxious but impotent spectator.

There are some morbid stimuli so very disproportioned to the interior force of resistance, that they instantly derange the vital actions to a point incompatible with a return to healthy function. Such, in many instances, is the contagious matter of plague; and some, also, of the poisons, animal, vegetable, and mineral. Over these causes medicine obviously can have no control.

Another class of diseases, which must ever baffle the skill of the physician, are such as are induced, not by violent, but by repeated stimuli. These, for the most part, arise from depraved habits, accompanied by the indulgence of some favourite propensity. The slightness of the shock, which is produced by each repetition of the noxious cause, prevents such a reaction of the living solids as is accompanied by pain or embarrassment in the leading functions: and the patient is seldom aware that he is seriously ill, until the whole machine is completely *detraquée*, and extensive injury is inflicted upon some principal organ.

A perfect and scientific system of medicine must necessarily be founded upon an intimate acquaintance with the laws of healthy functions. But how far we are at present removed from a perfect system of physiology, the reader must be thoroughly aware. The truth is, that by far the larger part of the practice of physic is empirical, being founded upon collections of observed facts, happy discoveries, or, perhaps, upon instinctive propensities.* There are few, if any, approved methods of treatment which rest exclusively upon *a priori* arguments, drawn from philosophical and scientific analogies. The treatment of fever by depletion, as it is practised at the present day, is strictly empirical. It was commenced by the school of Hippocrates in antiquity, but was afterwards abandoned in pursuit of the learned reveries of mere theorists. Sydenham, at the revival of learning, brought it into notice; when, after many revolutions of opinion, it again sunk beneath the speculations of Cullen and his antagonist Brown. Under the guidance of Hamilton, Currie, Mills, and other innovators, it has once more acquired its former pre-eminence; and, as it is to be hoped, will not be again forsaken, except upon grounds of an experimental increase in medical knowledge.

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* The abundant use of cold drink in fevers, (the "*dicta acquea*" of the Italians,) is a curative indication founded immediately in instinct.

The most consolatory side of the question is, that those diseases which originate in physical and in general causes, and from which human nature cannot escape, are the class most immediately within the dominion of the physician. Acute inflammatory complaints, which are relieved by depletion, and quenching the fire raised by excessive stimulation, are seldom obstinate, when attacked from their commencement with skill, and not suffered to injure the nervous tissues by their first violence. Gout, rheumatism, those nervous diseases which do not depend upon organic causes, and the whole tribe of chronic complaints, are the products of luxury on the one hand, and on the other, of the unnatural habits and over-strained exertions incidental to complex societies. Civilization, in the proper sense of the word, has hardly yet commenced. Moral and political science is yet in its infancy; the printing press is only beginning to produce the changes it is calculated to impose upon the species; public opinion is becoming hourly more enlightened, respecting the true interests of humanity; and false religion, false morality, and false policy are daily losing something of their hold on the understanding.

A better order of society must arise, and some return be made to the simpler and purer pleasures of nature. It is too much, indeed, to suppose that the passions of man will cease to exaggerate and mislead ; but they will become better directed, the relations of things to our organizations will be better understood, and experience will not for ever continue, as heretofore, to be lost upon humanity.

In estimating the value of the medical art, it is further necessary to separate what is accidental in disease, from what is essential to the human constitution. Infinite duration is not the attribute of natural combinations ; and with the most perfect system of medicine, man must still remain subject to death. The paths to decay are various; the animal not being a simple unity, but an assemblage of different organs, each of which may from its very origin have been defective. Every one of Nature's germs is not alike destined to receive its full developement ; and causes over which man has no control, must induce a premature old age in some subjects, and hurry them to the grave ere half the usual course of life has been run. For these cases the art is not to be taxed. In our most extensive operations upon nature, we are but obedient to its dictates ; and our part is ever secondary and subaltern. The limits of human power, it is true, are undefined ; nor can any scrutiny separate the diseases which are, from those which are not absolutely incurable. It is enough for the dignity of the profession, if it is upon a level with the natural science of its age; and in every condition of society it is entitled to respect; except when, in alliance with avarice and pretension, it addresses itself to the credulity, rather than to the reason of the invalid.

In the most general point of view, remedies operate either by deducting from the sum total of vital force of the whole animal, or of a particular organ, by counteracting diseased action, or by raising the sensibility so as to meet the increased expenditure of living energy. In some few instances, also, remedies are applied to favour the morbid action itself, when that action is experimentally known to terminate in the recovery of health.

The same surfaces which afford the most easy inlet to diseased impressions are the most susceptible of medicinal stimulation. It is to the skin, and the mucous membrane of the intestinal canal, that medicines are principally applied. The stomach and intestines are indeed so universally allied to the rest of the economy by their sympathetic energies, that there is scarcely a disease uninfluenced by alterations in their functional force.

When vascular action is excessive, the most powerful method of abating its intensity is by blood-letting. For the circulating fluid is at once the great source of vital energy, and the stimulus of the vascular system. The more rapidly blood is abstracted, the greater are the effects of the remedy. When it flows freely from a vein, a sudden diminution of organic tension occurs in the brain and nervous system, which suspends their functions; and in this interval of inaction the disease is not unfrequently arrested, and a return to health immediately commenced.

Medicines which quicken the functional actions of the intestines abate febrile irritation—first, by removing their natural secretions, which, being altered by disease, are in themselves a source of disturbance; secondly, by abstracting from the mass of the circulating fluids, to which end they co-operate with blood-letting; and, thirdly, by setting up a preternatural action in the abdominal organs, by rendering them a centre of fluxion, and thus abating the intensity of that cerebral excitement, which reacts so powerfully upon the heart and arteries.

Applications made to the skin are of singular efficacy in regulating internal functions. When heat is too rapidly generated by the febrile action of the capillaries, the affusion of cold water over the whole body restores the balance of action, and frequently cuts short the disease. When deep seated organs are the seats of malady, the warm bath, on the contrary, and the application of vapour, either generally or partially, by means of fomentations, may excite perspiration, determine from the diseased organ, and abate fever.

Warm and cold applications* may be applied locally; the one to establish a temporary fluxional action in remote organs, the other to repress vascular action in the immediate seat of the disease. For this purpose, ice and iced water may be used with the most decided benefit.

The application of blisters is regulated on similar principles; by rendering the skin the seat of inflammatory action, they frequently supersede disease in deeper seated parts.

There is a large tribe of medicines which operate upon the skin through its sympathy with the stomach. All nauseating medicines thus relax the exhalents on the surface, and induce a copious perspiration; which is among the most effectual means of diminishing febrile action, and should be employed wherever the use of the preceding remedies is counteracted by peculiar circumstances. The medicines of this class operate likewise upon the mucous membranes of the lungs and kidnies, and are employed whenever it is desirable to promote expectoration, or an increased flow of urine.

The use of the diffusible stimuli is confined to those cases in which the vital energy is inadequate to support the morbid excitement. Their repeated exhibition, by their peculiar action on the cerebral tissue, may support life, and maintain the combat until a favourable change in the malady shall determine a juster balance between force and function. Blisters applied to different parts of the surface in succession, are amongst the most valuable means of fulfilling this indication.

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* Applications to the surface may be either actually or potentially hot or cold. Stimulating remedies evolve heat upon the skin: astringent and sedative drugs produce cold.

The class of medicines, termed tonics, are of equivocal efficacy during the prevalence of disease; but their utility is marked in the period of convalescence. Their action upon the living tissues is wholly unknown.

Without descending more minutely into the details of medical science, which would only beget that "little learning," which is so dangerous, it must be manifest that medicinal applications are not made to diseases, but to functions. Diseases indeed are mere *entes rationis*, formed for the purposes of classification; and consisting of such groups of symptoms as most ordinarily occur together, but which, in point of fact, are seldom precisely alike. If the term disease have a real prototype in nature, it is when each separate symptom is considered as a distinct malady. Remedies therefore are only appropriated to the different combinations which figure in systems of nosology, inasmuch as they are calculated to act upon those functions whose defective or excessive action is most influential in causing the phenomena. The same remedy, therefore, is not effectual in every stage of disease, nor in every individual labouring under the same nominal complaints. A specific medicine, in the strictest sense of the word, does not exist, and the employer of quack remedies encounters the double risk of being mistaken in the complaint, and in the relation of the drug to the peculiar circumstances of his individual situation.

The general reputation of medicines of this class is founded in part upon the vast number of diseases, which, in themselves, are not fatal, and which recover, notwithstanding the employment of inert or inapplicable medicaments. In part also it rests upon the multitude of maladies for which no known remedy exists. It is the property of drowning despair to catch at every reed; and in the chronic and protracted sufferings of organic disease, it is natural to try whatever is proposed, and to imagine from each successive application in its turn a temporary relief. Quack remedies also derive considerable celebrity from gossiping recommendations. Idleness and imbecility seek occupation and consequence in the bustle and intrigue incident to this impertinent interference; and advice is proffered, and obedience exacted, with an intolerance and presumption proportionate to the ignorance, general and immediate, of the dictating autocrat. Fashion, likewise, the sovereign disposer of principles and of practice, for whom the fold of a riband is not too minute, nor the fortunes of a religion too immense, rules over the vast domain of medical prejudices with a tyrant's sway. Miracles are never wanting to sanctify each caprice as it arises, which, like the miraculous testimonies of false religions, afford sufficient evidence for those who choose to believe, but whch will be found, when the rage has subsided, to admit of sufficient doubt, to justify the ultimate neglect of the votaries of a newer and more fascinating idolatry.

The influence of the imagination in the cure of disease, contributes in a considerable degree to mislead enquirers into the efficacies of supposed specifics. It is well known that whatever excites a strong sense of horror and disgust will, by the shock it inflicts upon the system, break up concatenated actions, and produce a sudden revulsion of the whole economy. The swallowing of live spiders has been made the means of arresting ague, when physical agents have totally failed. Charms and amulets act by a similar agency on those who are weak enough to be duped into an opinion of their connection with awful and mysterious principles of action. Epilepsy, which, from its severe and appalling symptoms, was by the ancients deemed an immediate infliction of the gods, has been placed within the immediate province of superstition. Religious and magical applications have in all ages been employed for its cure: and by a singular coincidence, they are precisely the means most likely to remove the complaint in those cases, which, being independent of organic derangement, are at all susceptible of remedy. Epilepsy and other convulsive diseases are frequently caught by imitation, and are therefore more likely to be cured by mental impressions; but the influence of imagination over the functions, is not less evident in many other maladies, even of the nutrient system; as is shewn in those cases of emaciation and decay which have arisen from the maledictions of supposed witches, or from death-bed denunciations against uneducated and feeble-minded offenders. The metallic tractors and mesmerism derive all their power of influencing the economy from this inlet to impression. " C'est (dans mon opinion du moins) en mettant en jeu cette puissance, que les magnétiseurs opèrent les miracles qu'ils racontent, miracles tous produits sur des esprits mobiles, ou qui ont, au moins, un coté d'indécis."*

Here, for the present at least, the author proposes to rest. Much indeed remains to be said on the various subjects which have been treated of in the foregoing pages; but a slight essay has already grown into a ponderous volume. The scientific enquirer will perceive that a systematic treatise was not its object. Many details, and even entire subjects have been omitted, because they are ill adapted to unprofessional readers, more because they come not within the scope of the author's intentions. If the views which he has taken should lead the general philosopher to a nearer acquaintance with physical facts—if they should predispose to a more tangible, appreciable, tolerant and humane morality, than at present prevails in society—if they should open the eyes of a single legislator to the mischievous consequences of one existing prejudice in thought or action, or bring the mere man one step nearer to nature, their purpose will not be altogether unanswered. To liberal criticism the work is submitted with humility. To the petulant objurgator, the gad-fly of the moment, the author has only to observe with the Roman epigrammatist, " *Improbè facit qui in alieno libro ingeniosus est.*"

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* Montègre sur les Hemorroids.

THE END.